vol. iii

HOLLAND, John

THE

CABINET CYCLOPÆDIA.

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A TREATISE ON THE

PROGRESSIVE IMPROVEMENT & PRESENT STATE

OF THE

MANUFACTURES IN METAL.

VOL. III.

TIN, LEAD, COPPER & OTHER METALS.

H. Corbould del. E. Finden sc.

London:
PRINTED FOR LONGMAN, REES, ORME, BROWN, GREEN & LONGMAN, PATERNOSTER ROW, AND JOHN TAYLOR, UPPER GOWER STREET;
1834.

THE

CABINET CYCLOPÆDIA.

CONDUCTED BY THE

REV. DIONYSIUS LARDNER, LL.D. F.R.S. L. & E.

M.R.I.A. F.R.A.S. F.L.S. F.Z.S. Hon. F.C.P.S. &c. &c.

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EMINENT LITERARY AND SCIENTIFIC MEN.

Useful Arts.

A TREATISE

ON THE PROGRESSIVE IMPROVEMENT AND PRESENT STATE OF THE

MANUFACTURES IN METAL.

VOL. III.

TIN, LEAD, COPPER, BRASS, GOLD, SILVER, AND VARIOUS ALLOYS.

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"THESE ARE THE ARTS WHICH KEEP THE MASS OF THE PEOPLE IN USEFUL ACTION, AND THEIR MINDS ENGAGED UPON INVENTIONS BENEFICIAL TO THE WHOLE COMMUNITY; AND THIS IS THE GRAND PRESERVATIVE AGAINST THAT BARBARISM AND BRUTALITY WHICH EVER ATTEND AN INDOLENT AND INACTIVE STUPIDITY: THE DUE CULTIVATION, THEREFORE, OF PRACTICAL MANUAL ARTS IN A NATION, HAS A GREATER TENDENCY TO POLISH AND HUMANISE MANKIND, THAN MERE SPECULATIVE SCIENCE, HOWEVER REFINED AND SUBLIME IT MAY BE."

POSTLETHWAYTE'S DICT. OF TRADE AND COMMERCE,
voce ARTISAN.

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A

TREATISE

ON THE

MANUFACTURES IN METAL.

CHAP. I.

TIN MINES AND SMELTING.

ANTIQUITY OF THE CORNISH TIN MINES. — EARLY HISTORICAL NOTICES.—CASSITERIDES, OR TIN ISLANDS.—THEIR SITUATION AND IDENTITY. — FIRST STANNARY INSTITUTIONS. — TIN COINAGE AND DUTIES.—NEW CHARTERS AND REGULATIONS. — MINERALOGICAL CHARACTER OF CORNWALL. — ORES AND VEINS OF TIN.—ACCOMPANYING SUBSTANCES.—DESCRIPTION AND USE OF THE DIVINING ROD. — USUAL INDICATIONS OF METALLIC LODES.—HOW EXAMINED.—SINGULAR ENTERPRISE OF CORNISH TINNERS. — FAMOUS SUBMARINE MINE. — ORIGINAL STREAM-WORKS. — IMPROVEMENTS IN WORKING. — BLASTING, RAISING, AND PICKING THE ORES. — SMELTING FURNACES. — ECONOMICAL USE OF PIT COAL.

To the notices relating to the history, smelting, and manufacture of iron and steel, which have occupied two preceding volumes, may, without impropriety, immediately succeed an account of tin, this valuable metal

not only having been one of the most anciently discovered products of our native mines, and that which first attracted the commercial attention of foreign nations to Britain,—but one which is used in very large quantities in the plating of that beautiful preparation of sheet iron, which is itself commonly known in this country under the appellation of tin.

The English tin mines are in Cornwall and Devon, chiefly, however, in the former county, which forms the most westerly extremity of the island, jutting out into the sea between St. George's and the Irish Channels, somewhat in the form of a horn; from whence the common name of the county, as well as the Latin Cornubia, are generally supposed to be derived. At what era the trade in tin was first opened with foreigners, it is not possible to ascertain with accuracy; but, certainly, the period is as remote as the enquiry itself is interesting, for nothing is clearer than the fact, that this traffic existed contemporaneous, at least, with the very earliest glimpses of our history; indeed, Herodotus, who flourished about 450 years before Christ, mentions the tin islands of Britain, by their to him cabalistic synonyme of Cassiterides. The Phœnicians are allowed by general consent to have been among the earliest, if not indeed the very first, customers of the Cornubians for the valuable produce of their mines; and Sammes is of opinion, that these traders gave the present appellation to the county, during their intercourse with its inhabitants, from a word in the Phœnician language, signifying a horn, and indicative of the curved appearance of the coast as viewed from the sea. The Greeks residing at Marseilles were the next to visit Cornwall, or the isles adjacent, to purchase tin; and after them came the Romans, whose merchants were for a long period foiled in their attempts to discover the tin market of their commercial predecessors.

Camden says, "It is plain that the ancient Britons dealt in tin mines, from the testimony of Diodorus Siculus, who lived in the reign of Augustus, and Timæus,

the historian in Pliny, who tells us that the Britons fetched tin out of the isle of Icta (the Isle of Wight), in their little wicker boats covered with leather. The import of the passage in Diodorus is, that the Britons who lived in those parts dug tin out of a rocky sort of ground, and carried it in carts at low water to certain neighbouring islands; and that from thence the merchants first transported it into Gaul, and afterwards, on horseback, in thirty days, to the springs of Eridanus, or the city of Narbona, as to a common mart. Æthicus too, another ancient writer, intimates the same thing, and adds, that he had himself given directions to the workmen." In the opinion of the learned author of the Britannica, now quoted, and others who have followed him, the Saxons seem not to have meddled with the mines, or, according to tradition, to have employed the Saracens; for the inhabitants of Cornwall, to this day, call a mine that is given over working, *Attal-Sarasin*, that is, the leavings of the Saracens.

The islands alluded to by Diodorus, under the general appellation of Cassiterides, from κασσιτερος, tin, have generally been supposed to be the Scilly Isles, lying, as they do, west of the Land's End, and opposite to Celtiberia. The identity of these insular clusters has, however, been disputed, and lately, by the writer of a notice of Heeron's "Reflections on the Politics, Intercourse, and Trade of the Ancient Nations," in the Metropolitan Magazine. The reviewer says, "The ancient allusion to the islands called Cassiterides, with which the trade for tin was carried on, seems enveloped in considerable mystery; it is necessary to know something of the locality before an accurate judgment can be formed on this question. We do not believe tin was ever raised in the Scilly Islands; they are situated so far from the Land's End, that in very clear weather, at an elevation of between two and three hundred feet, we have been scarcely able to make them out. The rocks, sunken and apparent, and the currents, make the navigation between them and the mainland at all

times dangerous; and, unless in summer, frail canoes of hides could not live upon it. As to their having been accessible to wagons at ebb-tide, as Diodorus states, it is as much out of the question, as that Ushant is accessible from Plymouth in the same way; the coast is a terrific one, iron-bound, as the sailors say; and, in times when navigation is so well understood as at present, it is very dangerous, from the variations of tides and currents. We are of opinion that the present St. Michael's Mount is meant, which, at ebb-tide, is accessible from the mainland, where tin is found in two ways,—in stream-works and in mines. The Scilly Isles are mere rocks. St. Michael's Mount, it is true, is no more of itself; but we know that there was other land, perhaps isolated also, in Mount's Bay, and since submerged. In those days, we do not believe tin was found in mines, whence it is now taken in the state of ore: it was, in all probability, collected from the stream-works, as they are still called, in the form of what is denominated grain tin. These stream-works are horizontal excavations, open to the earth's surface, whence the tin is obtained by washing. The tin is found in this way, as gold-dust is met with in some parts of the world; and, indeed, in Cornwall too, for in these very stream-works the workpeople collect a grain now and then, and keep in a quill until it is full. These stream-works do not require machinery to descend into them or to drain them; pickaxes of holm, boxwood, and harts' horns, have been found in them often—the instruments of a rude people and age. Skin canoes or coracles could never have reached Scilly over the most turbulent of seas: may not Œstrymnon, in Avienus, mean the Lizard; the bay and isles, Mount's Bay? then all is accounted for. The character of the Atlantic Ocean, however, does not at present, and could then hardly have answered the description:—

> "Sic nulla late flabra propellunt ratem,
> Sic segnis humor æquoris pigri stupent,
> Adficit et illud, plurimum inter gurgites
> Extrare fucum, et sæpe virgulti vice
> Retinere puppim."

"The Atlantic and Bay of Biscay," adds the reviewer, "could have differed but little in those days from the present; the shore must have been kept in sight, and not approached near enough for the sea-weed to annoy the navigator; yet floating weed is no doubt intended. Himilco perhaps navigated in an unusually calm summer season." The least conclusive sentiment in the foregoing quotation, is that which rests a doubt upon the improbability of navigating such a dangerous sea as that which roars between the mainland and the Scilly Isles, in such frail barks as those alluded to by Diodorus. By those who recollect that the Greenlander will sail out more than twenty leagues a day in his frail kayack, and in which he sits upright amidst the roughest breakers, the probability of the hardy, adventurous, and almost amphibious Cornishmen, having in early times visited the Scilly Isles, and even Ireland, in their skin-covered coracles, will hardly be disputed.

To return to Camden:—he says, that after the coming in of the Normans, the earls of Cornwall derived vast revenues from the mines; especially Richard, who was brother to king Henry III. At this period Europe was not supplied with tin from any other place; for although there were mines in Spain, the incursions of the Moors had caused them to be closed or neglected, and the rich veins of this metal which were afterwards worked in Misnia and Bohemia, were not opened before about the year 1240. A writer of that age states, that "the metal called tin was found in Germany, by a certain Cornishman who was banished from his country, to the great damage of Richard earl of Cornwall." Neither at that time had tin been brought from the East Indies into Europe, as it was in after years, in considerable quantities. A charter of the mines was obtained by Edmund, earl Richard's brother, with several immunities: the Stannary laws were likewise framed by him, and confirmed under his own seal, laying a certain impost upon the tin, payable to the earls of Cornwall.

These liberties, privileges, and laws, which are particularly recited in Plowden's Commentaries, were afterwards confirmed and enlarged by Edward III.; who divided the whole society of tinners (till then forming, as it were, one body), into four parts, called, from their localities, Foymore, Blackmore, Trewarnail, and Penwith. He constituted one general warden or overseer over all the rest, to do justice in cases both of law and equity, and to set over every company a subwarden; these, every month, within their respective jurisdictions, were to determine all controversies: from these sentences or stannary judgments, however, an appeal might be made to the lord warden himself.

According to ancient custom, forty shillings were paid upon every thousand pounds of tin to the dukes of Cornwall; and lest the revenues of the duchy should suffer, it was provided, that whatever tin was made should be carried to one of five towns, appointed for the purpose, where twice every year it was weighed and stamped, and the impost paid, before which, whoever should sell or carry it away was subject to a severe fine. The stamp was the seal of the duchy, and the coinage towns Liskeard, Lostwithiel, Truro, Helstone, and Penzance.* In the time of Edward I. Bodmin was one of the five coinage towns; but in the next reign, upon a petition to the king and council, made by the men of Lostwithiel, it was given in favour of that place, and Bodmin deprived of the privilege. There were also two other coinages, called by the tinners post-coinages, and for which they paid four-pence upon every

* In the "Beauties of England and Wales," edited by Messrs. Britton and Brayley, it is stated, under the article *Truro*, that "there only, and at Penzance, with the exception of a few times at Helstone, for the convenience of the merchants, have the coinages of late years taken place. Most of the tin is coined here, and more is exported hence than from any other port in the county. The blocks lie in heaps about the streets, and are left entirely unguarded, as their great weight renders it difficult to remove them without immediate detection. Here is a coinage hall; and Hals, in his Parochial History, mentions the town possessing one so early as the reign of king John. There is also a manufactory for converting block tin into bars and ingots; the weight of the former is from eight ounces to one pound; that of the latter, from sixty to seventy pounds. The bars are exported to the Mediterranean and Baltic; the ingots are sent to the East Indies."

hundred-weight of metal; these were at Lady-day and Christmas. After the coinage and other legal duties were satisfied, the tinner was at liberty to sell his tin as he thought fit, except the king or duke had a mind to buy it, for to them appertained the right of pre-emption.

The disputes that have from time to time arisen between the miners and the duchy need not be particularly mentioned in this place. It may, however, be mentioned, that prince Arthur, eldest son of king Henry VII., stretching his jurisdiction as duke of Cornwall, made certain constitutions relating to the stannaries, which the tinners refused to observe. After the death of the prince, Henry, who seldom let slip any opportunity of filling his coffers, taking a liberty that was not justifiable by their charters, made the opposition to the late prince a pretext to take the stannaries into his own hands. But finding that they did not turn to so much account as he had expected, he submitted to accept of 1000*l.* for all pretended forfeitures, granting likewise his charter of pardon. By that charter he further granted, that no law relating to the tinners should be made without the consent of twenty-four stannators, and those to be chosen by the mayor and council of a borough in the four divisions, six individuals out of each. The charters which had been granted in the thirty-third and in the fiftieth years of the reign of Edward III., and by which the tinners of Cornwall obtained liberties distinct from those of Devonshire, were revised, confirmed, and the jurisdiction of the stannaries restrained, in the seventeenth of Charles I. His present majesty, it may be proper to mention, is duke of Cornwall.

The original stannary laws, and the privileges belonging thereto, were in the beginning common to Cornwall and Devonshire, tin works being largely carried on in both counties. But, according to bishop Gibson's version of Camden, "though Cornwall has now the greatest share in these mines, there being little

or no tin made in Devonshire, yet in king John's time there was more found in that county than in Cornwall. For it appears that the coinage of Devonshire was then set to farm for 100*l.* per annum, whereas that of Cornwall yielded but 100 marks. And, according to this proportion, the tenth thereof (6*l.* 13*s.* 4*d.*) is at this day paid by the crown to the bishop of Exeter. But king John did not first bestow these tenths upon the church, as some say, for he only restored them, upon a complaint made by the bishop, that those who rented the stannaries refused to pay him his due."

The county of Cornwall abounds with mineralogical productions, probably to a greater extent, and including a larger variety of substances, than almost any other tract of like size in the world. The general appearance, too, of the surface is strikingly indicative of the fact, that beneath rather than upon that surface are we to look for the riches of the inhabitants. The chief metalliferous strata, however, stretch from the Land's End in the west, in an easterly direction, through Devonshire. The principal seat of the mines, at present, is in the neighbourhood of St. Austel, and westward towards the sea; those on the northern side of this mining tract of about seven miles in breadth, being latterly the most productive. Speaking of this locality, the author of the General View of Cornwall strikingly remarks, "In a narrow slip of barren country, where the purposes of agriculture would not employ above a few thousand people, the mines alone support a population estimated at nearly 60,000, exclusive of the artizans, tradesmen, and merchants in the towns of St. Austel, Truro, Penrhyn, Falmouth, Redruth, Penzance, and some others."

The tin ores of Cornwall are found in veins or fissures, locally called *lodes;* and the direction of these fissures is mostly east and west: in this manner they frequently pass through a considerable tract of country with very few variations, unless interrupted by some intervening cause. But, besides this east and west di-

rection, there is what the miners call the underlying, or *hade* of the vein, which is a deflection of the lode from the perpendicular line. This slope generally trends north or south, but its direction is by no means uniform, for it will frequently underlie a small space in different ways, appearing as though it had been forced to either side. Sometimes the deviations of the lodes are wavy, making large curves, where they cross a valley; and in almost all cases the lesser veins branch from the great lodes like the boughs of a tree, the ramifications diminishing as they extend in distance, till they terminate in threads.

Veins of tin are considered to be worth working when only three inches wide, provided the ore be good; some of the mines, however, have very large veins, from which, as just stated, the smaller ones diverge. These veins sometimes cross each other, either horizontally or in their perpendicular descent, when they are called *contras* by the miners; sometimes, too, a promising vein will suddenly disappear, without giving any warning, by becoming narrower, or of worse quality; this occurrence is called by the workmen a *start*, and is no ways uncommon in the Cornish mines. Thus, in a single day, a rich vein of tin may suddenly terminate, and leave the miner no clue by which to proceed in his attempts to rediscover the infracted stratum. A body of clay or other matter appears to interpose, and although the search is generally pursued, either by working in the direction of the vein, or by sinking a new shaft from the surface, mortification and loss not seldom terminate an adventure, the commencement of which was highly encouraging. It may be further mentioned, that tin is sometimes found collected and fixed, and sometimes loose and dilated. "In the former state it is either in a lode or *floor*, which is a horizontal layer of the ore, or interspersed in grains and small masses in the natural rock. The floors are frequently deep, and very rich; but the expense of working them is generally considerable, from the quantities of large timber necessary to

support the several passages of the mine. The same lode that has continued perpendicular for several fathoms, is sometimes found to extend suddenly into a floor. Tin, in its dispersed form, is either met with in a pulverised sandy state, in separate stones, called *shodes,* or in a continued course of stones, which are sometimes found together in such numbers, that they reach a considerable depth, and are found from one to ten feet deep. This course is called a *stream;* and when it produces a large quantity of the metal, it is denominated *Beukeyl,* which is a Cornish word, signifying a *living stream;* and in the same figurative language, when the stone is but lightly impregnated with tin, it is said to be *just alive;* when it contains no metal, it is called *dead;* and the heaps of rubble are emphatically called *deads.*

"The streams are of different breadths, seldom less than a fathom, and often scattered, though in different quantities, over the whole breadth of the moor, bottom, or valley, in which they are found: when several streams meet, they frequently make a very rich floor of tin. Huel-Jewell, near the Gwenap mines, is famous for producing tin-crystals, in the substance called by the miners *growan,* which is nothing more than a decomposed granite, consisting of transparent quartz, a small portion of decomposing felspar, and silvery mica, partly in a decayed state. The crystals are resin-coloured, and are scattered throughout the whole mass in the shape of tetrahedral pyramids, and their modifications, with and without the intermediate prism. The famous *wood-tin,* as it was called, from the appearance of wood which some of the pebbles exhibited, was formerly found in the Loth stream-works in abundance, but all these works have been washed away in violent storms. It was nearly the colour of hæmatites, with fine streaks or striæ, converging to the different centres like the radiated zeolite. From the experiments of Klaproth, it was found to yield sixty-three parts in a hundred of tin. The most common state in which tin is found in this county is the *calciform,* the greater quantity of

ore being indurated or glass-like; and its most prevalent matrix is either an argillaceous or a silicious substance, or a stone composed of both, and called by the miners *caple;* none of the calcareous genus ever appears contiguous to the ore, except the fluors. The oxides of iron and arsenic are those with which the tin is most frequently blended."

Before adverting to the signs that are allowed in general to indicate the proximity of a favourable spot for sinking a mine, it may be proper to mention, that formerly, and even to this day by some persons, implicit faith attached to the use of the *virgula divinitoria,* or divining rod; nor was this superstition by any means confined to the ignorant or the illiterate, but extended to the best informed even of the overseers themselves. Even Pryce, one of the most scientific and experienced miners of Cornwall, appears to have been an inflexible believer in the extraordinary effects of this rod, the use of which, although of great antiquity in foreign countries, was introduced into this only in the reign of queen Anne by a renegade Spaniard of the name of Riberia. Pryce thus describes the construction and use of the rod: —" The rods formerly used were shoots of one year's growth that grew forked; but it is found that two separate shoots, tied together with some vegetable substance, as pack-thread, will answer rather better than those which are grown forked, as, their shoots being seldom of equal length or bigness, they do not handle so well as the others, which may be chosen of exactly the same size. The shape of the rods thus prepared will be between two and a half and three feet long. They must be tied together at their great root ends, the smaller being to be held in the hands. Hazel-rods cut in the winter, such as are used for fishing-rods, and kept till they are dry, do best; though, where these are not at hand, apple-tree suckers, rods from peach-trees, currants, or the oak, though green, will answer tolerably well. It is very difficult to describe the manner of holding and using the rod: it ought to be held in

the hands, the smaller ends lying flat or parallel to the horizon, and the upper part in an elevation not perpendicular to it, but seventy degrees.

"The rod being properly held *by those with whom it will answer*, when the toe of the right foot is within the semi-diameter of the piece of metal or other subject of the rod, it will be repelled towards the face, and continue to be so while the foot is kept from touching or being directly over the subject; in which case it will be sensibly and strongly attracted, and be drawn quite down. The rod should be firmly and steadily grasped, for if, when it hath begun to be attracted, there be the least imaginable jerk or opposition to its attraction, it will not move any more till the hands are opened and a fresh grasp taken. The stronger the grasp the livelier the rod moves, provided the grasp be steady, and of an equal strength." Scepticism seems, in the opinion of this simple-minded Cornishman, to be destructive of the effect of the divining rod, just as sir Thomas Brown tells us, that the man who, doubting the existence of ghosts, should wish to see one for his conviction, shall never be gratified. Pryce goes on to say, "A little practice by a person in earnest about it, will soon give him the necessary adroitness in the use of this instrument; but it must be particularly observed, that as our animal spirits are necessary to this process, so a man ought to hold the rod with the same indifference and inattention to, or reasoning about it, or its effects, as he holds a fishing-rod or a walking stick; for if the mind be occupied by doubts, reasoning, or any other operation that engages the animal spirits, it will divert their powers from being exerted in this process, in which their instrumentality is absolutely necessary: from hence it is that the rod constantly answers in the hands of peasants, women, or children, who hold it simply, without puzzling their minds with doubts or reasonings." Nearly thirty years ago, when Warner visited Cornwall, many surprising stories were told to confirm the accounts given of the powers of the *virgula divini-*

toria; and at that time, he said, " implicit credit was given to the virtue of the rod by *all* persons concerned in the Cornish mines: most of the workmen were firm believers in it; but many of the captains were sceptical; and all the proprietors absolute infidels in this respect."

Although there is no rule by which the existence of a vein of tin can certainly be determined by the appearance of merely superficial signs, yet there are various indications that rarely fail to point out the proximity of a lode when near the surface: these are, the barrenness of the spot; the presence of shattered fragments of the *shodes* or stones already mentioned; or, sometimes, the harsh metallic taste of the water of some adjacent spring. More generally, however, the richest lodes owe their discovery to accidental causes, such as the breaking of rocks, the washing away of sea-cliffs, and still more frequently in the working of drifts or adits: these being cut in a direction north or south often intersect rich veins at right angles. After a spot containing ore has been discovered, the next consideration is, how or whether a mine may be wrought with advantage. In order to determine this question, the projector will duly weigh all circumstances connected with the place, more particularly its situation as to wood, water, carriage, healthiness, and the like, and compare the result with the richness of the ore, the charge of digging, stamping, washing, and smelting.

The situation of the spot should particularly be considered. A mine, generally speaking, will occur, 1. in a mountain; 2. in a hill; 3. in a valley; or, 4. in a flat place. On many accounts, especially before the introduction of the steam-engine, mines in mountainous situations were worked with much more ease and economy than others, on account of the convenience which they afforded, as well for the scooping out of horizontal gangways for the bringing forth of the ore, as for the more difficult perforation of drains to carry off the water. Elevated situations are moreover found to be healthier than others that lie low. The immense

steam-engines now erected to raise the water have rendered the working of the mines somewhat less dependent on situation; though sometimes, now as formerly, the adits, or drifts for the emission of the water, are carried for a mile or two through hard rock, at an enormous expense.

It is a most remarkable fact, that not only in hills and valleys, and from the plains, have the enterprising explorations of the tinners been conducted — some of the Cornish mines have actually been carried to a considerable distance under the sea; some of these submarine excavations, as described by Mr. Hawkins, display, in a striking manner, the effects of perseverance and the defiance of danger on the part of the miners: for instance, the noted mine of Huel-Cok, in the parish of St. Just, which descends eighty fathoms, and extends itself forward under the bed of the sea, beyond low water mark. In some places, the miners have only three fathoms of rock between them and the sea; so that they hear very distinctly the movement and the noise of the waves. This noise is sometimes terrible, being of an extraordinary loudness, as the Atlantic Ocean is here many hundred leagues in breadth. In the mine, the rolling of the stones and rocks overhead, which the sea moves along its bed, is plainly heard; the noise of which, mixed with the roaring of the waves, sounds like reiterated claps of thunder, and causes both admiration and terror to those who have the curiosity to go down.

In one place, where the vein was very rich, they searched it with imprudence, and left but four feet of rock between the excavation and the bed of the sea. At high water, the howling of the waves is heard in this place in so dreadful a manner, that even the miners who work near it have often taken to flight, supposing that the sea was going to break through the weak roof, and penetrate into the mine.

A very singular circumstance at Huel-Cok is, that in some places, under the bed of the sea, where there is only a small thickness of rock between the mine and the

water, in one place not more than four feet, but a very small quantity of water enters the mine by leakage. When the miners perceive any chinks which might give it a passage, they stop them up with clay, or with oakum. The like method is used in the lead mines of Pava Labalon, which also run under the bed of the sea. The mine of Huel-Cok has now been abandoned many years, on account of the danger, which continually became more menacing.

But the most singular work of this kind was executed more than a century ago, in the midst of the sea, near the port of Penzance. At low water in this place, a gravelly bottom was left bare, in which was discovered a multitude of small veins of tin ore, which crossed each other in every direction. The adjacent rock also contained this mineral in considerable quantities; they worked this rock whenever the sea, the time, and the season would permit, until the depth became too great.

The place where this submarine tin ore was found was about 200 yards from the shore; and as the bank of the sea in this place is very steep and high, this distance is considerable, even at low water; and at high water is covered by the sea six yards deep. As the bottom is gravelly, and full of rocks, the waves become much agitated, and rise to a great height, when the wind blows from particular points. This inconvenience takes place throughout the winter, and had always led to the failure of the different attempts which had been made before to drain the mine and raise the ore. At low water mark, the rock rises a little above the surface of the sea; nevertheless, there is not ten months in the year in which it is uncovered.

Against all these difficulties, a single individual, whose property was not worth three crowns, and who undertook the work anew, had to contend. This courageous miner employed three summers in sinking a pit, during which time he could only work two hours a day, and every time when he went to work, he found his excavation full of water. This he was obliged to empty

out before he could recommence working, which occasioned still greater difficulties when he set about blasting the rock.

At first he had only need of strength and patience; but when he sank to a greater depth, he added to them ingenuity. He built round the mouth of the pit a turret of wood, impervious to the water, and by this means was able to prolong the time of working on the rock. He further endeavoured to shut out the water entirely from his pit, by raising the turret above the greatest height to which the sea could reach.

But here he had new difficulties to conquer: first, to make this turret impervious to water; and secondly, to stay it in such a manner, that neither the flux nor reflux of the sea, or the shocks of the waves, could overturn it. The enterprising miner had provided against these difficulties. The rock was, fortunately, of porphyry, not too hard to cut, but still very firm. He shaped the portions he separated from it, and disposed them in a regular manner, at the bottom of the turret, and closed and caulked with oakum and fat cement all the interstices between the wood and the stone, so that the whole was united into one mass. The pit, like all those in Cornwall, was lined with planks; all the joints being well caulked and pitched. When his framework was thus constructed, he supported it with iron braces. About the mouth of the pit he raised, upon four great piles, a platform of planks, to support the windlass, which was worked by four men. This work, as may be imagined, took much time, and met with many mishaps in the execution; but the perseverance and presence of mind of the undertaker conquered all obstacles. When the pit and tower were finished, he then reaped the fruit of his industry, and established a regular work at Stockwork, drew from it in a little time a considerable quantity of tin, and put his adventure on a good footing.

There were times, however, when his undertaking was not in such a good state. To save expense, and dimin-

ish his labours, he attacked the part of the mine overhead, by which means, at high water, the sea penetrated through the chinks of the rock, so that he was obliged to sustain the roof, which was pretty extensive, in some parts, by planks and thick props, to prevent the great mass of water which pressed on it above, from driving it in. Besides this, notwithstanding all his endeavours, it was not possible for him to keep his wood-work watertight in the winter; and when the sea was rough, he could not transport the ore ashore in his boat. In the autumn of 1790, the chamber excavated in the inside of the rock had the following dimensions:—

Greatest depth - -	36 feet.
Depth to the level of the passage -	26 feet.
Greatest diameter of the chamber -	18 feet.
Least diameter - - -	3 feet.

Four men, in two hours, emptied the pit of water by the windlass, at the rate of four tons in a minute; towards the end of which time, six men drove it from the bottom of the pit, and poured it into the passage. After drawing off the water, they worked six hours more on the rock. From one tide to another, they raised about thirty sacks of ore, each sack containing fourteen gallons, fifteen sixteenths of which were so rich, that they produced one-sixth of a hundred-weight of tin, and one sixteenth of a hundred was procured from the remaining part; so that in six months they raised to the value of 600*l.* sterling of tin. As most of the ore was interspersed in a hard rock, difficult to pound, the undertaker had it roasted in a common lime-kiln, which answered perfectly well. There had been nothing of the kind done in Cornwall before. This singular work was known by the name of *Huel Ferry:* the persevering individual who planned and executed it, died at the age of seventy years, in the winter of 1791; the mine having in the preceding summer yielded ore worth 3000*l.*

Notwithstanding, however, this prodigious effort of

ingenuity and perseverance, and others that might be mentioned in connection with mines opened in modern times, there can be no doubt but the original tinmen of Cornwall confined their operations almost entirely to the collection and reduction of such ores as were most easily accessible, more especially to the *stream-works*, as they have long been called, not in the mining sense, in which the terms imply a living stream of ore, but as meaning simply the conducting of a current of water over a bed of tin, and which, by washing away the lighter matter, leaves the metal to be picked up where the operation has been carried on. When, in process of time, pits were sunk in those places where the manifest abundance and richness of a vein led the miner to penetrate beneath the surface, the produce was raised by being thrown upon successive stages or platforms, or *shammels*, as they were called in Cornwall, by men arranged at different elevations. How great an improvement upon that tiresome method must have been the introduction of the windlass, even in its rudest form, may easily be conceived. By means of the well known contrivance just named, and which was probably brought from Germany, not only was the raising of the solid contents of the excavation amazingly facilitated, but, what was of equal importance, the water was cleared out of the mines, by means of buckets, with a degree of despatch that had not before been practised.

Pumps worked by men, water-wheels, or horses, were subsequently introduced to drain the mines; and ultimately, the steam-engine was employed for this important purpose; and it should be observed, that during what may be called the infancy of this noble prime mover, and before its powers and its precision had been applied to the driving of rotatory machines, the proprietors of the Cornish mines were among the earliest and most ready promoters of its uses, during the successive stages of its improvement, from its rudest to its comparatively perfect construction. At the present moment, some of the largest engines in the world are

employed in drawing the water from the tin and copper mines of Cornwall.

In many instances the working of the mines is still carried on by means of the old-fashioned windlass, but more generally with the *whim*, or *whimsey*, or, as the contrivance is called in the north of England, when driven by a horse, a *gin*. The whim is composed of a perpendicular axis, on which turns a large hollow cylinder of timber, called the cage, and around this a rope winds horizontally, being directed down the shaft by a pulley fixed perpendicularly over the mouth of it. In the axis of the cylinder a transverse beam is fixed, at the end of which two horses or oxen are fastened, and go their rounds, hauling up a bucket or *kibble* full of ore, or rubbish, while an empty one is descending. In some mines the whim is worked by steam.

Until the seventeenth century, the methods of detaching the masses of ore inside the mine were as imperfect as the modes of raising it to the surface were rude. Tools of iron had superseded the implements of bone, and even of wood, which the ancient miners used; but, notwithstanding picks and wedges of metal enabled them to attack the harder substances in which the ore was embedded, it was not until the introduction of gunpowder, about the year 1684, that the workmen were fully enabled with facility to detach, by gunpowder, the hardest, and sometimes, also, the richest masses. Some notion may be formed of the extent to which this irresistible agent is employed, from the fact, that, for many years together, an expenditure of 40,000*l.* per annum, for gunpowder alone, has been incurred by the Cornish miners.

At present, therefore, the ore is blown out of the rock by this means; and, when raised from the mine, is divided into as many shares (or *doles*) as there are lords or adventurers: these lots are measured out by barrows, an account of which is kept by a person who notches a stick. "Every mine possesses the privilege of having the ore distributed on the adjacent fields.

The ore is generally pounded or stamped on the spot, in the stamping mill. If full of slime, it is thrown into a pit called the *buddle,* to render the stamping more free without choking the grates. These grates are thin plates of iron, about one foot square, full of small holes nearly the size of a moderate pin, but sometimes larger, as the different sizes of the tin granules require. If free from slime, the ore is shovelled into a kind of sloping canal of timber, called the pass, whence it slides by its own weight, and the assistance of a small stream of water, into the box where the *lifters* work. The lifters are raised by a water-wheel, and are cased at the bottom with large masses of iron, nearly $1\frac{1}{2}$ cwt. in weight, which pound or stamp the ore small enough for its passage through the holes of an iron grate fixed in one end of the box. To assist its attrition, a rill of water keeps it constantly wet; and it is carried by a small gutter into the *fore-pit,* where it makes its first settlement, the lighter particles running forwards with the water into the *middle-pit,* and thence into the third, where what is called the slime settles. From these pits, the ore is carried to a large vat called the *keeve,* and is here washed from all its filth, and rendered sufficiently clear for the smelting-house. Among the variety of curious minerals with which Cornwall in common with most mining districts abounds, may be mentioned, as occurring almost continually, is a splendent species of pyrites called *mundic,* which often impoverishes the quality of the tin, and renders it quite brittle, while at the same time it requires to be separated from the ore by the noxious and tiresome process of roasting, preparatory to its being smelted. "So dreadfully deleterious," says Dr. Maton, "are the fumes of arsenic, constantly impregnating the air of these places (the *burning-houses*), and so profuse is the perspiration occasioned by the heat of the furnaces, that those who have been employed at them but a few months become most emaciated figures, and in the course of a few years are generally laid in their graves."

The smelting establishments consist either of capacious reverberatory furnaces heated with coal, or of what are called blowing-houses, from the fire being urged by a blast. The fuel is commonly charcoal. The largest erection of the former kind in the county is that called Calinnick, about a mile from Truro: it comprises ten or twelve furnaces, each six feet high, and nearly twelve feet in length; here "culm-coal is used as the flux, in the proportion of about one-eighth to the ore, of which nearly 600 cwt. is smelted within six hours, and yields about 350 cwt. of tin. The blowing-houses are near St. Austel; and in some of them cylinders are used, and in others huge bellows."

The tin is run from the furnaces into moulds, yielding blocks weighing from $2\frac{3}{4}$ cwt. to $3\frac{3}{4}$ cwt. each. These blocks or pigs, after being coined, are either sold entire, or again recast into small rods to suit foreign markets. One of these rods, on being bent backwards and forwards, yields a singular crackling sound, and at the same time gives out a peculiar odour. The following were the prices of British tin on board ship in 1832: in blocks per cwt., *3l.* 12*s.* 6*d.*; ingots ditto, *3l.* 13*s.*; in bars, *3l.* 14*s.* 6*d.*; grain blocks, *4l.* 13*s.*; broke, *5l.* 3*s.* Notwithstanding the productiveness of her own mines, Great Britain imports upwards of 700 tons per annum of oriental, or, as it is more commonly called, Banca tin, from the name of one of the Malay islands where it is chiefly obtained. The Malay countries are reckoned the richest depositories of this metal in the world, and from them China, Hindostan, and many European markets are chiefly supplied. England exports annually about 2000 tons of tin, including 400 or 500 tons of that received from abroad.

Authorities are not agreed as to the time when pit-coal first began to be substituted in the reverberatory smelting-houses for wood or charcoal; though this is generally supposed to have been about 1680. The question, as to the discovery of this economical and useful fuel as proper for the fluxing of tin ore, lies be-

tween Pryce, in his account of the mineralogy of Cornwall, and Beecher, an ingenious German, who, after various persecutions in his own country, came over to Cornwall, where he introduced several improvements into the method of mining. Beecher's account of the matter, and for which he quotes no authority, is contained in the following words:—"Ignis usus, ope, flammarum lithantracum stannum et mineralia fundendi, Cornubia hactenus incognitas, sed a me introductus." On the other side, Pryce says expressly that "necessity at last suggested the introduction of pit-coal for the smelting of tin ore; and, among others, to sir Bevil Grenville of Stow, in this county, temp. Car. I., who made several experiments, though without success: neither did the effectual smelting of tin ore with pit-coal take place till the second year of queen Anne." In the smelting of this as of other metals, the application of this fuel has been productive of immense advantages; and such is the perfection to which our metallurgic operations have been carried since the economical introduction of this cheap and plentiful fuel, that the regulations of our custom-house alone prevented the carrying a scheme set on foot some years ago, for the importing of the tin ore from the Eastern mines, for the purpose of being smelted in this country, and afterwards re-exported.

CHAP. II.

TIN PLATE WORKING.

VALUABLE PROPERTIES OF TIN. — ARTICLES OF SOLID TIN NOT COMMON. — TIN FOIL. — USE OF TIN FOR COATING OTHER METALS. — PROBABLY KNOWN TO THE ROMANS. — TINNED VESSELS NOT FOUND IN HERCULANEUM. — TINNING OF SHEET IRON LONG NEGLECTED BY THE ENGLISH. — INTRODUCTION AND SUCCESS OF THE MANUFACTURE. — ENGLAND SURPASSES EVERY OTHER COUNTRY IN THE QUALITY OF HER TIN. — TINNING SMALL WARES. — PREPARING IRON PLATES FOR TINNING. — ROLLING, PICKLING, AND SCOURING. — DIPPING. — ARRANGEMENT OF THE TIN POTS. — CLEANING AND PACKING THE PLATES. — PRICES OF SHEET TIN. — FORMATION OF TIN VESSELS. — SOLDERING. — BLOCK-TIN WARES. — BEAUTY AND LIGHTNESS OF TINNERY.

It would be tedious to recapitulate in this place the substance of the various discussions which have taken place, as well in this as in other countries, upon the question as to whether the valuable metal now universally known as tin was in reality the *cassiteron* of the Greeks, and the *stannum* of the Romans; or whether these terms may not in the first instance have been applicable to the mixture of lead with silver, which was very common among the ancients, and still more so of late years in Germany, under the designation of *werk*, of which vessels of all kinds, similar to the pewter wares formerly used in this country, were manufactured. Of the composition of this *werk* we shall speak hereafter, when treating of the smelting of lead. Of this there seems to be no doubt; namely, that whatever may have been the specific metal called *plumbum album* and *plumbum candidum* by Pliny, and of which the *vasa stannea* of the Latin authors were made, that the

earliest method of using tin for the fabrication of vessels would be by casting; a process of which the nature of the metal itself would at once suggest the practicability. It has, nevertheless, been noted as a remarkable circumstance, that vessels of tin have rarely been found among Greek or Roman antiquities, and that, when so discovered, the nature of the metal has often been very doubtful, though tin is less apt to change from the action of the air, water, or earth, and, at any rate, far surpasses in durability copper and lead, ancient articles of which are frequently found. It possesses also so many excellent properties, that the people of every age to whom it was known, would, as we may suppose, have employed it in a variety of ways. It recommends itself by its superior silvery colour, its ready fusion, the ease with which it can be hammered and twisted, its lightness, and its durability; it is not soon tarnished; it is still less liable to rust or to become oxygenated; it not only retains its splendour a long time, but when lost easily recovers it again. Yet, notwithstanding these valuable properties, the comparative ignorance of the art of economical casting among the ancients, the value of tin, as compared with what must have been the weight of articles thus formed, and the probable absence of those methods of uniting beauty with lightness, which the application of the rolling mill, the stamp, and the lathe, has placed within the reach of modern ingenuity, especially in the manufacture of what is called Britannia metal, may well enough account for the rarity of ancient specimens of solid tin ware. In this country, indeed, the consumption of tin in the manufacture of articles composed exclusively of this metal, is very inconsiderable; the greater portion so used is in the state of leaves, or what is called tin-foil. For this purpose the metal is either expanded by means of rolling or hammering, or by these operations combined, until it is hardly the 1000th part of an inch in thickness; this is the substance which, covered with a portion of mercury, composes what is called the "silvering" of looking-glasses:

the best of the ancient metallic mirrors or specula, were also made of a mixture of tin and copper. It has also another and very important use in the economy of our national manufactures: the solutions of tin in the nitric, muriatic, and nitro-sulphuric and tartaric acids, are much used in dyeing, as giving a degree of permanency and brilliancy to several colours, not to be obtained by the use of any other mordants. Joyce says, that in combination with sulphur it constitutes what has been called mosaic gold.

One extremely important application of tin, and which the moderns have carried to great perfection, is in coating other metals; and it is questionable how far or whether at all the ancients were acquainted with this beautiful and economical use of tin, or whether they formed the bodies of vessels entirely of this substance, as of the other metals with which they were acquainted. It has been supposed that the *vasa stannea* of the Romans may rather have been vessels of copper *tinned* on the inside, than cast, or otherwise made entirely of the metal from whence they derived their appellation; just as we at the present time apply the term tin to articles the substance of which is iron. Copper vessels thus coated were undoubtedly in use among the Romans, and the economy and utility of such a combination of the two metals ultimately led to that most valuable discovery, the art of coating sheet iron with a brilliant and immoveable pellicle of tin. Of the process employed in tinning in ancient times, we have no account; but the words of Pliny, *incoquere* and *incoctilia*, seem almost to denote that it was performed, as in tinning our iron wares, by immersing the vessels in melted tin. It appears also to have been done, at an early period, in a very perfect manner; both because the tinned articles, as Pliny says, could scarcely be distinguished from silver, and because the tinning, as he adds, with an expression of wonder, did not increase the weight of the vessels. The metal, therefore, was applied so thin that it made no perceptible addition to the weight; this,

it may be remarked, is still the case, when the process of tinning is skilfully executed, and it affords one of the most striking proofs of the astonishing divisibility of metal. Dr., afterwards Bishop Watson, caused a vessel the surface of which contained 254 square inches, and which weighed twenty-six ounces, to be tinned, and found that the weight was increased only half an ounce; consequently, half an ounce of tin was spread over 254 inches, and yet every part was covered.

But notwithstanding all the dexterity which must be allowed to the Romans, they appear, as Beckmann justly remarks, to have employed tinning, at any rate for kitchen utensils and household furniture, very seldom. It is scarcely ever mentioned, and never where it might be expected; that is to say, in works on cookery and domestic economy, where the authors give directions for preparing and preserving salt provisions. When they speak of the choice of vessels, they in general, merely say that new earthen ones should be employed. Dioscorides the physician recommends tinned vessels; but it does not appear, though copper vessels were much in use among the Romans, that they employed any precautions to prevent them from being injurious to the health. Pliny only says that a coating of *stannum* improved the taste of food, and guarded against verdigris, which must have been a disagreeable, if not a deleterious, concomitant of the use of brazen vessels. It has been remarked that, among the many copper vessels found at Herculaneum, though some are said to have been silvered, none of them were tinned.

From the practice of tinning vessels of copper, to the art of performing a similar operation upon plates of iron, the transition may at first appear to many persons to be very trifling indeed. Such, however, is by no means the fact; for, with respect to the latter metal, there arose not only the additional difficulty of spreading out the bar, by means of hammering, into laminæ sufficiently thin and smooth; but the formidable task of brightening the surface, in some instances, by the

laborious process of filing, as well as the difficulty of always securing an uniform adhesion of a film of tin over the entire surface of the sheet. It has already been mentioned that British tin was for a long time sent into Germany, from whence this country imported plated or tinned iron; and to Germany or Bohemia must in all probability be referred the invention of an art now become of such great utility, and in the practice of which the English workmen have long been acknowledged to surpass those of every other country. The art of tinning is said to have been carried from Bohemia into Saxony, about the year 1620, by a catholic clergyman, who had embraced the Lutheran religion.

It is remarkable that the English, although they had so long a monopoly of the tin trade, and moreover possessed the richest mines in the world, should nevertheless have failed, as it appears, until a comparatively recent period, in their attempts at tin plating. Beckmann states that, about the year 1670, a company sent to Saxony, at their expense, an ingenious man named Andrew Yarrenton, in order to learn the process of tinning. Having acquired there the necessary knowledge, he returned to England with some German workmen, and manufactured tin plate which met with general approbation. Before the company, however, could carry on business on an extensive scale, a man of some distinction having made himself acquainted with Yarrenton's process, obtained a patent for this art; and the first undertakers were obliged to give up their enterprise, which had cost them a great deal of money; and yet no use was made of the patent which had been obtained. Such is the account of the matter, as it stands in the authority quoted: we may, however, reasonably doubt its absolute correctness; especially the intimation that the process carried on by the English adventurer and his German colleagues was patented to an individual who himself purloined it.

More certain and remarkable is it that, about the year 1720, which, on account of the many new schemes

and the deceptive trade carried on in consequence of them, will ever be memorable in the history of English folly — among the many bubbles, as they were then called, was the formation of an establishment for making tin plate: and this was one of the few speculations of that period which were attended with advantage. The first manufactory of this kind was established in Monmouthshire, at the village of Pontypool, where tin plate was afterwards so extensively and successfully prepared. Towards the latter end of the last century, tin plate works were erected in this country, almost wherever the manufacture of iron was largely carried on; the perfection of the method of laminating the metal by means of rollers having more than any thing else contributed to the success of these undertakings. The French were still later in their acquisition of the art of tinning iron; in France, the first experiment to introduce this branch of manufacture, was made under Colbert, who procured German workmen, some of whom were established at Cheseney, in Franche Compté, and others at Beaumont-la-Ferriere in the Nivernois. But the want of skill and proper support rendered this expensive undertaking fruitless. Some manufactories, however, were afterwards brought to be productive, the oldest of which was established at Mansvaux in Alsace, in the year 1733: this was followed by another at Bain in Lorraine, which obtained its privilege from duke Francis III.; and this was confirmed by Stanislaus in 1745. The French call tin plate by the expressive appellation of *fer-blanc*, or white iron, which is exactly answerable to the *ferrum candidum* of the ancients, and a hundred talents of which were given as a present to Alexander in India: it is not reasonable, however, to suppose that this resemblance goes further than the coincidence of terms, although it is difficult to guess what sort of metal the white iron of India can have been.

Previous to describing in detail the method of preparing tin plate, as practised in this country, it may be

remarked that the chief peculiarity of the manufacture, apart from the rolling of the plates, consists in taking advantage of that chemical affinity which subsists between tin and iron. One of the strongest proofs of this affinity is derived from the circumstance, that even cast iron may be tinned in the same manner as wrought iron. Of late years, cast-iron saucepans, and pots of a large size, are permanently tinned on their inner surfaces, to prevent whatever may be boiled in them from acquiring any stain by a partial dissolution of the iron. Many other articles, such as bridle bits, common stirrups, small nails, &c. are now made much cheaper than formerly, by first producing them in cast iron, and then covering them with a thin coat of tin, by immersing them in a hot mass of that fluid metal.

The following ingenious method of tinning nails, tacks, and other small wares, is given by Mr. Gill, in the Technical Repository:—first, clean the surface of the articles to be tinned from rust or other oxide, by pickling them in sulphuric or muriatic acid, diluted with water as usual: then, washing them well afterwards in water, put them into a stone ware gallon bottle, together with a proportionate quantity of bar or grain tin, and of sal-ammoniac: next place this vessel, lying upon its side, over a charcoal fire, made upon a forge hearth, and keep turning it round, and frequently shaking it, to distribute the tin uniformly over the surfaces of the articles to be tinned: lastly, throw the articles into water, to wash away all remains of the sal-ammoniac, and finally dry them in saw-dust made warm. The great merit of this process consists in the employment of the stone ware vessel, which not only prevents the dissipation of the sal-ammoniac in fumes, but also gives up the whole of the tin to the articles to be tinned, which would not be the case were a metallic vessel to be used.

The most accurate account that has appeared of the several processes which are usually pursued in the manufacture of tin-plate, was communicated by Mr. Parkes

the chemist, in the Memoirs of the Literary and Philosophical Society of Manchester. That article, and information derived from a personal inspection of a tin-plating establishment of considerable extent, will be the sources from whence the following details are drawn. The first thing to be attended to, is the preparation of the latten, or leaves to be tinned; for this purpose the rich Welch iron, or at least English iron of the finest quality, and known in the trade as tin-iron, being such as is generally prepared with charcoal instead of coke, must be selected for this operation. This material is received either in long flat bars, or in rough slabs called blooms; these latter pieces being about thirty inches in length, six inches wide, and weighing eighty pounds: after being made red-hot, these are passed repeatedly between rollers, until reduced to about three eighths of an inch in thickness. When cooled, the pieces are applied to a pair of massy shears, worked by machinery, and cut into lengths ten inches by six: these, by being passed many times through the fire, and between the rollers, are reduced to as thin a state as the process will conveniently admit: the sheet of metal is then doubled, and again rolled out until it will extend no more, when it is doubled again, and the operation of rolling repeated upon the quadrupled sheet. It is then carried to the cutting room, where a man, with the assistance of stout shears, pares off the jagged edges, and reduces the whole to a certain size, after which, having cut the piece across, he rips asunder the laminæ into eight separate sheets. As the workman shears the plates, he piles them in heaps, occasionally putting one plate cross-ways, to indicate the quantity technically called a box, and consisting of 225 plates.

The plates are now taken from the shear-house by a workman called the *scaler*, who, preparatory to their being *cleansed*, bends them singly across the middle into the shape of a gutter-tile, thus, ∩. The cleansing, as it is called, is commenced by steeping the plates for the space of four or five minutes in a leaden trough, con-

taining a mixture of muriatic acid and water, in the proportion of four pounds of acid to three gallons of water: this quantity of the diluted acid will generally be sufficient for 1800 plates, or eight boxes. When the plates have been steeped for the time prescribed, they are taken out of the liquor, and placed upon the floor three in a row, and then, by means of an iron rod put under them, they are conveyed to a reverebatory furnace or brick oven heated red-hot, where they remain until the heat causes to fall off a thick scale, the removal of which was the object in submitting them to this high temperature. In this oven they are placed in rows, three in each row; and it is here, as well as in the previous process of pickling, that the convenience of the plates being bent will be apparent; for it is obvious that, if they lay flat on the bottom of the oven, the flame which detaches the scale could play only on one side of the metal, whereas, by being bent, as already described, the flame can operate equally on both sides. When the plates are taken from the oven, they are placed on a floor to cool; after which they are straightened and beaten smooth on a cast-iron block. The workman knows by the appearance of the plates during this operation, whether they have been well scaled; for if they have, that is, if the rust or oxide which was attached to the iron has been properly removed, they will appear mottled with blue and white, something like marbled paper.

As it is impossible the plates can go through the foregoing process without being in some measure warped, or otherwise disfigured, they are now again passed singly between a pair of hard polished rollers, about eighteen inches long, and thirty inches in diameter. These rollers are used without heat, but they are screwed very close one upon the other, so that the utmost pressure may be given to the plates. This operation is called *cold rolling;* and not only gives a high degree of smoothness to the plates, but likewise communicates that peculiar elasticity which belongs to them.

When the plates have undergone the last-mentioned process, they are put one by one into troughs, filled with a liquid preparation called the *lyes*. This is merely water in which bran has been steeped for nine or ten days, until it has acquired a sufficient acidity for the purpose. The design of putting the plates into the troughs *singly*, is, that there may be more certainty of the liquor getting between them, and both sides of the plates being acted upon by the lye. In this liquor they remain for ten or twelve hours, standing on the edges; but they are turned or inverted once during that time.

The next operation is called *pickling*, and consists in submitting the plates to the effect of a mixture of sulphuric acid and water, in proportions varied according to the judgment of the workman. The trough in which this operation is conducted is composed of thick lead, and the interior of which is divided by partitions of the same metal. Each of these divisions is by the workmen called *a hole*, and each of them will contain about one box of plates. In the diluted sulphuric acid, contained in the different compartments of this vessel, the plates are agitated for about an hour, or until they have become perfectly bright, and entirely free from the black spots which are always upon them when they are first immersed in it. Some nicety, however, is required in this operation, for if the plates remain too long in the acid, they will become stained by it, or blistered, as the workmen term it; but practice enables a careful operator to judge of the time when they ought to be removed. It may be remarked that both this and the former process with the acidulated water, are hastened by giving to the menstrua an increase of temperature, by means of heated flues running under each trough.

When the plates come out of the pickle, they are put into pure water, and scoured in it with hurds and sand, to remove any remaining oxide or rust of iron that may be still attached to them; for wherever there is a particle of rust, or even dust upon them, there the tin will not fix; they are then put into fresh water, to be there

preserved for the process of tinning. The design of putting the plates into pure water after they come out of what is termed *the sours,* is to prevent their becoming again oxidated; and it is remarkable that, after these operations, they will acquire no rust, although they should be kept twelve months immersed in water.

It will be perceived that all these processes are nothing more than preparatory measures for the operation which is to succeed, viz. that of tinning.

For this purpose, a strong cast-iron bath, capable of containing 200 or 300 sheets of metal, and about five cwt. of molten tin, is fixed so as to be heated from a fire-place undeneath it, and by flues which go round the pot or bath. This tin pot is nearly filled with a mixture of *block* and *grain*-tin, in about equal proportions, and a quantity of tallow or grease, sufficient, when melted, to cover the fluid metal to the thickness of four inches, is put to it. The use of the grease is to preserve the tin from the action of the atmosphere, and, consequently, to prevent it from oxidating. The workmen also say that it increases the affinity of the iron for the tin, or, as they express it, that it makes the iron plates take the tin better. It is curious that *burnt grease,* or any kind of empyreumatic fat, effects the purposes better than pure fresh tallow.

Another pot, which is placed beside the tin-pot, is filled with grease only; and in this the prepared plates are immersed, one by one, before they are treated with the tin; and when the pot is filled with them, they are suffered to remain in it so long as the superintendent thinks necessary. If they remain in the grease an hour, they are found to tin better than when a shorter time is allowed them.

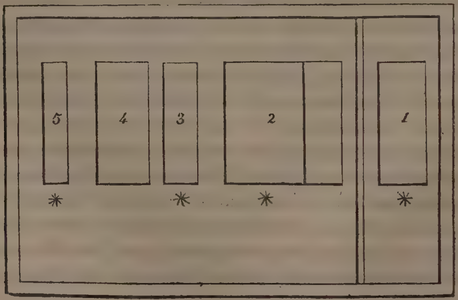
From this pot they are removed, with the grease still adhering to them, into the bath before mentioned as containing the body of melted tin: and in this they are placed in a vertical position, from 200 to 300 or more occupying the receptacle at once; and, for the sake of their being thoroughly tinned, they usually remain in it

one hour and a half; but occasionally more time is required to complete this operation. The metal is kept as hot as it can be made without inflaming the grease on its surface.

When the plates have lain a sufficient time immersed in the melted tin, they are taken out by means of tongs, and placed upon an iron rack or grating, that the superfluous metal may drain from them; but, notwithstanding this precaution, there is always twice or three times as much metal adhering to them as is necessary, and this is taken off by a subsequent process, called *washing*. As this process is rather complicated, it will be necessary to describe it with some minuteness.

In the first place the wash-man prepares an iron pot, which he nearly fills with the best grain tin in a melted state; another pot of clean melted tallow, or lard free from salt; a third pot with nothing within it but a grating to receive the plates — and a fourth, called the *listing-pot*, with a little melted tin in it, about enough to cover the bottom to the depth of a quarter of an inch. The whole will, however, be better understood by referring to the following delineation (*fig.* 1.), in which the several vessels are exhibited in the order in which they stand in the manufactory, all supported by substantial brickwork, and at a height most convenient for the operations of the workmen.

Fig. 1.



The building in which the pots are fixed is called the *stow:* the plates are worked from the right hand to the left of the stow, as will be evident by attending to the uses of the separate pots:—

No. 1. represents the tin-pot.
2. the wash-pot, with the parting within it.
3. the grease-pot.
4. the pan, containing a grating at the bottom, and designed for the reception of the plates as the boy takes them out of the grease-pot: it has no fire underneath it.
5. the list-pot. In the plan the asterisks show the places where the workmen stand, and also indicate those pots which have heated flues under them.

The parting in the wash-pot number 2. is a recent improvement. The design of it is to keep the dross of the tin from lodging in that part of the vessel where the last dip is given to the plates. By using the *common* tin in the first process of tinning, much oxide or dross adheres to the surface of the plates, and this runs off in the wash-pot, and comes to the face of the new metal; but this partition enables the operator to prevent it from spreading over the whole surface of the pot. Were it not for this partition, the wash-man must skim the oxide off the fluid metal every time he puts plates into it.

The pots, arranged according to the foregoing sketch, being in a state of fitness, the wash-man commences his part of what remains of the business, by putting the plates which have undergone the various operations hitherto described into the vessel containing grain-tin, and called the wash-pot. It should be remarked, that none but grain-tin is ever put into this vessel, for the whole of the common tin which is consumed in this manufacture is used in the first process, viz. that which is called tinning. The heat of the large body of wash-tin soon melts all the loose tin on the surface of the plates, and so deteriorates the quality of the whole mass, that it is usual, when sixty or seventy boxes have been

washed in the grain-tin, to take out the quantity of a block, say 300 cwt. and replenish the wash-pot with a fresh block of pure *grain*-tin. These vessels generally hold three blocks each, or about half a ton weight of metal. That which is taken out of the wash-pot, when it is replenished with pure metal, is given to the tin-man to put into his pot.

When the plates are taken out of the wash-pot, they are carefully brushed on each side with a brush of hemp of a peculiar kind, and made expressly for the purpose. This operation is thus performed:—the wash-man first takes a few plates out of the pot, and lays them together before him on the stow; he then takes one plate up with a pair of tongs, which he holds in his left hand, and, with the brush in his right, sweeps one side of the plate; he then turns it, and repeats the operation on the other side, and immediately dips it once more into the hot fluid metal in the wash-pot, and, without letting it out of the tongs, instantly withdraws it again, and plunges it into the grease-pot (marked No. 3). A person who has not seen the operation can form but a very inadequate idea of the adroitness with which this is performed: practice, however, gives the workman so much expedition, that he is enabled to make good wages, although he obtains only three-pence for the brushing and metallic washing of 225 plates. An expert wash-man, if he make the best of his time, will wash twenty-five boxes, consisting of 5625 plates in twelve hours; notwithstanding every plate must be brushed on both sides, and dipped twice into the pot of melted tin.

As a reason why the plates are dipped twice, it must be recollected that they are brushed quite hot, and before the tin is set; therefore, if they had not the last dip, the marks of the brush would be visible. Moreover, the brush takes the greater part of the tin off them, so that if they were removed to the grease-pot without being re-dipped, the hot grease would take off what remained.

The only use of the grease-pot is to take off any superfluous metal that may be upon the plates: but this

is an operation that requires great attention, because, as the plate is immersed in the grease while the tin is in a melting, or, at least, in a soft state upon it, a part must run off, and the remainder become less and less while the plate continues in it; therefore, if ever these plates should be left in the melted tallow longer than is absolutely necessary, they will doubtless require to be dipped a third time in the tin. On the other hand, if the plates were to be finished without passing through the grease, they would retain too much of the tin, which would be a loss to the manufacturer; and besides, the whole of the tin would appear to be in waves upon the iron.

It is important that the temperature of the melted tallow should be attended to, it being required to be hotter or colder in proportion as the plates are thinner or thicker; for if, when the tallow is of a proper temperature for a thin plate, a thick one was to be put into it, it would come out, not of the colour of tin, as it ought to be, but as yellow as gold. The reason of this is evident: the thick plate contains more heat than a thin one, and, consequently, requires the tallow to be at a lower temperature. On the contrary, if a parcel of thin plates were to be worked in a pot of tallow which had been prepared for thick ones, such a pot would not be hot enough to effect the intended purpose.

In consequence of the plates being immersed in the melted tin, and subsequently in the grease-pot, in a vertical position, there is always, when they have become cold, a list or selvage of tin on the lower edge of every plate, which is removed in the following manner:—An assistant, called the list-boy, takes the plates when they are cool enough to handle, and puts the lower edge of each one by one into the list-pot, which is the vessel before described as containing a very small quantity of melted tin, and marked No. 5. When the list is melted by this last dip, the boy takes out the plate, and gives it a smart blow with a thin stick, which disengages the superfluous metal; and this falling off, leaves

a faint stripe in the place where it was attached; and this list-mark may be discovered on every tin plate which is exposed for sale.

The final operation is to cleanse the plates from the grease; for this purpose they are handed, while warm, to women, who instantly place them in bins of dry bran, with which, by means of hards, they are rubbed until they are quite clean, and present that silvery appearance which is so characteristic of the best English tin plate, and which is allowed to surpass in beauty that manufactored in any other country. Tin plates are sold in boxes made either of strong wood, or, as they have frequently been made of late years, of sheet iron. Each box contains a determinate number of plates; and the following table, as compiled by Mr. Parkes, will show the sizes of tin plate which are made in Great Britain, and the marks by which each kind is known in commerce, with the current wholesale price per box in London in 1832; between which period and the year 1817 the scale of prices, as exhibited in the last column below, exhibits a decrease of twenty per cent.

Names.	Sizes.	No. in a Box.	Weight of each Box.			Marks put on the Boxes.	Prices per Box. 1832.
	Inches.		cwt.	qrs.	lbs.		Shillings.
Common, No. 1. -	13¾ by 10	225	1	0	0	CI	32
Common, No. 2. -	13¼ by 9¾			3	21	CII	30
Common, No. 3. -	12¾ by 9½			3	16	CIII	28
Cross, No. 1. -	13¾ by 10		1	1	0	XI	38
Two cross, No. 1. -			1	1	21	XXI	44
Three cross, No. 1.			1	2	14	XXXI	50
Four cross, No. 1.			1	3	7	XXXXI	56
Common doubles -	16¾ by 12½	100		2	21	CD	28
Cross doubles - -			1	0	14	XD	34
Two cross doubles			1	1	7	XXD	40
Three cross doubles			1	2	0	XXXD	46
Four cross doubles			1	2	21	XXXXD	52
Common small doubles - -	15 by 11	200	1	2	0	CSD	54
Cross small doubles			1	2	21	XSD	60
Two cross doubles -			1	3	14	XXSD	66
Three cross doubles			2	0	7	XXXSD	72
Four cross doubles			2	1	0	XXXXSD	78
Wasters, common, No. 1.	13¾ by 10	225	1	0	0	WCI	29
Wasters, cross, No. 1.	13¾ by 10		1	1	0	WXI	35

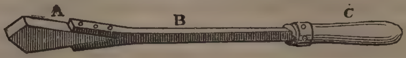
The art of tin plate working, or the forming of the material into that immense variety of economical utensils, so common in every dwelling-house in the kingdom, depends much more on the manual dexterity of the workman than upon any peculiarity in the tools which he requires. The latter are few and simple, including bench and hand shears, mallets and hammers, steel heads and wooden blocks, soldering iron and swages.

In the formation of a vessel, the plate is first cut to the proper size or pattern with shears; and when the article designed requires more than a single sheet, others are joined, either by simply overlaying the edges and soldering them down, or by folding them together and then perfecting their adhesion by means of a running application of the soldering iron: a similar course is adopted when gores or other pieces are to be inserted. A can or other vessel of capacity, or cylindrical article of any sort, is rounded on a block or maundrel with a mallet, and the seams finished as already described; after which it has to be wired at the mouth or any outer edge which it may present. For this purpose, a piece of iron wire, generally about the size of a knitting needle, but thicker for utensils that are very large, or designed to bear considerable stress, is bent into the requisite shape, and, on being applied to what might be called the raw edge of the metal, a portion just sufficient to cover the wire is dexterously folded over it by means of the hammer. The insertion of this wire not only adds greatly to the beauty of the workmanship, but it preserves the shape of the article, and contributes amazingly to its strength and durability; it is, therefore, the universal border of tin wares, even those of the cheapest quality. It may be observed that tin plate is the only metal that is soldered by laying the edges one over the other; tubes of silver, copper, brass, and even lead, being usually joined by bringing the edges exactly into contact, and an alloy afterwards melted along the seam.

The instrument used by the tinman for uniting pieces

of plate by means of heat is called a soldering iron, and is, in most cases, nearly of the following shape (*fig.* 2.), and about sixteen inches in length.

Fig. 2.

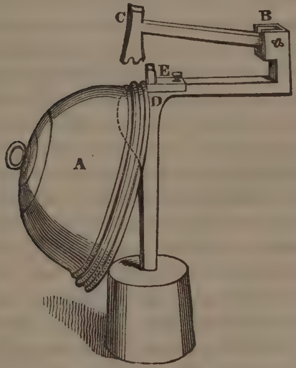


A is the tongue of copper, sloped away at the end, in order that it may be the more easily applied in soldering angular seams. B an iron shank, into the mouth of which the wedge of copper is riveted. C is a wooden haft, by means of which the instrument is used in the hand when heated nearly to red-hot. Copper is preferred on account of its great affinity for tin; so that, in uniting pieces of plate, the solder instead of spreading away from the heated piece, and falling down or bespattering the work, as it would if the heater were of iron, adheres to it, and, consequently, may be drawn along the seam or picked up in small portions with surprising ease. The end of the copper bit is, therefore, kept constantly tinned: but as this cannot be well done by merely dipping it in the solder, nor unless the metal be clean, the following method is adopted: — the solder, which is composed of two parts tin, and three parts lead, run into slips, on being applied to the heated copper, which is rubbed in a hollow stone containing a quantity of rosin and solder, the tongue of the instrument is presently tinned, and ready to be used for soldering. The iron, as it becomes cool, is successively re-heated in the fire, and again rubbed in the rosin and solder upon the stone as above stated: the sprinkling of a little powdered sal ammoniac upon the point of the instrument facilitates the tinning.

Besides the endless variety of cheap wares manufactured immediately from the plate as above described, there is a superior kind of workmanship adapted to the formation of what are called *block-tin* goods. The material in both cases is usually the same, but in the latter mode of working it is beaten or planished on a

metal stake with a polished steel hammer, in the manner of silver plate; so that the surface, instead of appearing somewhat wavy, as it does in the best unplanished wares, is perfectly smooth and silvery, particularly after being polished with dry whiting. This peculiarity, with the additional care bestowed in fabricating articles by this method, not only renders them more desirable to those persons who wish for beauty along with utility, but causes them to sell at far higher prices than the common tin plate articles of exactly the same form and substance. It is in block-tin working that ornamental swaging is commonly applied. This process consists in placing the metal intended to be grooved or ridged between two steel dies or bosses, the upper being a short stout lever, made to play up and down against its counterpart below.

Fig. 3.



A (*fig.* 3.) represents a dish cover placed under the metal swages B, for the purpose of having the moulding on its edge raised to the proper degree of elevation. C is the swage hammer, the steel face of which is cut or filed in parallel grooves, according to the position of the swell intended to be produced. At D there is a pro-

jection of the metal extending under the article to be swaged, and the face of which is formed in convex swells, exactly according with the grooves in the face of the hammer C. E is a guide, which, by means of a screw, admits of being moved so as to regulate the depth or width of the moulding. It was formerly the practice to solder these mouldings upon large articles, such as dish covers, until, some years since, Mr. King, a tinman in Holborn, introduced the practice of swaging them. As, however, the mouldings upon his articles were very bold and handsome, he effected that appearance by the following process: — having first formed the cover by hollowing, planishing, and fitting together its parts in the usual manner, and soldered them in their plain hemispherical form, he places the sides of the article upon a concave bed of lead, having a hollow line sunk in it, and, by the application of a bouge hammer inside, the rim is neatly raised to the extent required; after which it is placed under the swages, by means of which the parallel courses are produced, and the whole moulding rendered smooth, uniform and perfect. The swages are used either by striking upon the head with a mallet, or by merely working the swage-hammer itself, the article operated upon being advanced a little after every stroke. Bright block-tin dish covers, of graduated sizes, are now to be seen in almost every respectable house in the kingdom, from the kitchen of the humblest tradesman to that of the peer himself: to the former party, covers of no other material, equally cheap, can be offered; and the latter does not always find it convenient to substitute for this fine, clean, and durable tinnery the more expensive fabrics of silver, or even double-plated copper.

An endless variety of articles, as well useful as ornamental, are formed by embossing tin plate in dies, either by means of the stamp, or the fly-press — commonly the latter. A prodigious quantity of coffin plates of a cheap description are manufactured at Birmingham by this method: these, and other like matters, are sometimes

lacquered, painted, or japanned, according to circumstances. An exceedingly beautiful style of ornamenting the better sort of tin wares by a peculiar crystallization on the surface has been invented within the last few years.

The duration of tin vessels is very considerable when they are carefully used, especially for purposes where cleanliness does not require that they be frequently scoured: where this is the case, and when Calais sand, instead of whiting, is applied, the coating of tin is soon rubbed through, the iron appears, and the utensil, although not weakened, acquires rust, and perishes on continued exposure to moisture. While perfectly coated, however, no material is a more efficient security against the access of oxidating influences, even of sea-water itself: hence polished steel cutlery, when sent out to the East Indies, is invariably soldered up in cases of tin plate.

The comparative lightness of this ware, as in common use, may be judged of from the fact, that an ordinary wooden bucket, holding four gallons, weighs eleven pounds; while a tin can of similar capacity weighs only about six pounds. Next to the extreme lightness of vessels of tin, as compared with those of wood, and which renders the former so desirable for the carrying of water, milk, and other liquids, may be mentioned their sweetness and freedom from deleterious qualities, particularly so long as the coating of tin remains perfect. An opposite opinion was at one time promulgated; for not only were untinned vessels considered to be detrimental to health, but likewise those in which any portion of lead was mixed with the tin: this notion, however, has been shown to be erroneous even if the two metals be used in equal quantities.

CHAP. III.

LEAD.

PECULIARITIES OF LEAD.—EARLY NOTICES OF LEAD.—NIGRUM PLUMBUM.—GALENA AND STANNUM.—ENGLISH LEAD DISTRICTS.—HIGH PEAK.—MINERAL LAWS.—STOWSES.—GETTING THE ORE.—TYTHE.—SALES OF ORE.—BOLES, OR WIND HEARTHS.—CUPOLAS.—PROCESS OF SMELTING.—WEIGHT OF THE INGOTS, OR PIGS.—DIFFERENT QUALITIES OF LEAD.—IMPORTATION FROM SPAIN.—DEPRESSION OF THE LEAD TRADE.—EXPORTATION AND RECENT PRICES.

Lead is one of the softest, most ponderous, most widely diffused, and, generally speaking, best known of the perfect metals: to the latter distinction the large place which it occupies in the materia of the useful arts is mainly conducive. For the purposes to which iron is generally appropriated, lead would be utterly inapplicable; while to many of the uses for which the precious metals are consumed lead might be applied, and, in fact, it has, with or without its various alloys, been largely so applied in former times, and continues to be in request for such purposes at the present day. Lead, when newly melted, is very bright, a good deal resembling tin, but less silvery: on cooling, however, it soon becomes tarnished, and on exposure to the air assumes that dull blueish hue, so well known under the denomination of *lead colour*. The temperature at which lead melts is much higher than that which is required for the fusion of tin; the latter metal liquefying at 442° of Fahrenheit's thermometer, the former requiring 612°. Lead is the most malleable of all the metals; it may be spread out by hammering with the greatest ease, and the slightest stroke is sufficient to indent a solid lump: it is remarkable that, under the hammer, it neither becomes harder, nor is its specific gravity increased, as is the case with other metals upon

which beating produces the effect of compression. Although its ductility is not great, it may nevertheless be drawn into wire in which state its tenacity is considerable: it is, under any circumstances, elastic only in the most trifling degree, and, of course, equally insonorous.

That lead was well known, and in common use in very early times, we have abundant testimony of various kinds: it is mentioned early and repeatedly in our version of the Bible; nor can there exist much doubt that the terms which our translators have rendered by lead do really apply to this metal. Two questions, however, have arisen on this subject; in the first place, whether we should not, in the passages where *tin* is mentioned in our Scriptures, understand lead of some kind, and not the metal to which the moderns give the name of tin, and which it has been supposed could hardly have been known to the old Hebrews and their contemporaries; and, in the second place, whether the descendants of Abraham, and other nations of antiquity, were not acquainted with a peculiar sort of lead, to which they gave a specific epithet, and the meaning of which has been confounded with appellations applied in later times to the metal which we call tin. The word which Hebrew lexicographers define to be tin, is, in the original, *bedil;* and this term the Greek translators of the sacred books undoubtedly rendered *cassiteros,* and, therefore, they seem to have considered the two metals as identical, whatever they might have been; and, as more modern writers translated *cassiteros* by *stannum,* these words have found their way into the Latin, German, and other versions of the Hebrew Scriptures; so that very little reliance should be placed upon the mere occurrence of a word, only so far as it certainly does, in the original, indicate some metal different from gold, silver, copper, and even ordinary lead.

In the opinion of Beckmann, to whose ingenious chapter on the early knowledge and use of tin reference has been made before, the *stannum* of the ancients was no peculiar metal, at any rate not our tin, but rather a

mixture of two other metals, which, like our brass, was made into various articles and employed for different purposes; on which account a great trade was carried on with it. This, at least, may, with apparent certainty, be inferred from a well-known passage in Pliny:— "Plumbi nigri origo duplex; aut enim sua provenit vena, nec quidquam aliud ex se parit; aut cum argento nascitur, mixtisque venis conflatur. Ejus qui primus fluit in fornacibus liquor stannum appellatur; qui secundus, argentum; quod remansit in fornacibus, galena, quæ est tertia portio additæ venæ. Hæc rursus conflata, dat nigrum plumbum, deductis partibus duabus." Here, then, whatever literal difficulties beset the passage, we have the fact, that the same furnace yielded from the same ore stannum, argentum, galena, and nigrum plumbum. To comprehend this, it is necessary to know that tin ores rarely, if ever, contain silver; while there are few lead ores but what are impregnated with it, and many of them so largely, that they might with more propriety be called silver ores, or rather argentiferous lead, or plumbiferous silver ores.

It may, as Beckmann observes, appear singular that the ancients should have had *nigrum plumbum*, undoubtedly our lead, in such abundance that Pliny was able to make of it a particular division. But, in ancient times, people paid little attention to a small admixture of silver; they were accustomed to separate the precious metal, in general, only when it was capable, by the old, imperfect process of smelting, to defray the expences: which would certainly not be the case, when a quintal of ore contained only a few ounces, or even a pound of silver. Strabo says this expressly of some Spanish ores. Such poor ores were then used merely for lead; and hence it has been supposed that our expert refiners, might separate silver with considerable advantage from the lead of the ancients. Hence has also arisen the opinion entertained by some, that lead, and also copper, with which some very old buildings have been covered, had, in the course of time, become argentiferous: absurd

as this notion may be, it might no doubt be possible to separate from them the noble metal; which the ancients either could not do, or did not think it worth the trouble to attempt.

Besides, therefore, what was considered the pure saleable lead, which flowed immediately from the ore on its first fusion, the ancients obtained; as we do, a great deal of lead from argentiferous ores, from which they separated the silver and revived the lead. The ore was pounded very fine, or, as we say, stamped; it was then washed and roasted, and formed into a paste; this was then put into the furnace, and, by the first fusion, gave a regulus consisting of silver and lead, which was called stannum, and was a substance similar to that known to the German metallurgists by the name of *werk*. The produce obtained by the second fusion was the *argentum*, silver, called in German *treiber;* and besides that the half-vitrified lead called *galena* by Pliny, and also *molybdæna;* which substance, being once more fused, or revived, again yielded lead. In contending that our tin was not originally meant by the first use of the term undoubtedly applied to it in latter times, Beckmann adds: — "In my opinion the oldest *cassiteron* (of the Greeks) was nothing else than the *stannum* of the Romans, the *werk* of our smelting-houses; that is, a mixture of lead, silver, and some other accidental metals. That this has not been expressly remarked by any Greek writer, is, to me, not at all surprising. We should not have known what *stannum* was, had not the only passage of Pliny which informs us been preserved."

Whatever the metal at first called *bedil* by the Hebrews, *cassiteron* by the Greeks, and *stannum* by the Romans may have been, whether our tin, or lead alloyed with silver and other metals, it is certain that lead, properly so called, was well known to the people of antiquity, and by them no doubt used for many of the more familiar purposes to which it is devoted in modern times. Ores of lead, as already stated, occur in most

parts of the world, and mostly in abundance: they are generally met with in veins, sometimes in siliceous rocks, and sometimes in calcareous strata. Their specific characteristics are considerably diversified, whether occuring as sulpherets, oxides, or salts; the first species, however, is the most common, including the varieties of galena, as well crystallised as in masses.

Of the lead districts in this country the most noted are, the Mendip Hills, in Somersetshire, about Hexham, in Northumberland, and the High Peak, in the county of Derby. The Mendip mines were formerly very famous; and there is an account of the manner of working them in the Philosophical Transactions for 1668, written by Mr. Glanvil, which appears to have coincided in simplicity with the practice then adopted in all the mining and smelting operations of our ancestors. "The ore lies in veins as a wall: 'the clearest and heaviest is the best; of which 36 cwt. may yield a ton of lead. The workmen beat the ore with a flat iron, then cleanse it in water from the dirt, and sift it through a wire sieve. The ore tends to the bottom, and the refuse lies at top: and these are the preparations they make use of before it is fit for fusion. For this purpose they have a hearth about five feet deep, set upon timber, to be turned as a windmill, to avoid the inconvenience of smoke upon a shifting wind. The hearth contains half a bushel of ore and coal (charcoal), with bellows on the top, worked by men treading on them. The charcoal is put upon the hearth where the ore is, laying dry sticks of oak upon the top, which they call their white coals. There is a sink on the side of the hearth, into which the lead runs, that holds about a hundred and a half. Then it is cast into sand, forming what are called sowes. They have a bar to stir the fire, a shovel to throw it up, and a ladel heated red-hot to cast out the melted metal. Once melting is enough; and the best, which is heaviest, melts first."

The celebrated and picturesque district, so well known to tourists as the High Peak, and designated in the

records of the duchy of Lancaster "The King's Field," comprises, under its peculiar mineral laws, the greater part of the extensive mountain limestone tract of Derbyshire, and is peculiarly rich in lead. According to the aforesaid laws, which bear characteristic traces of having originated at a very early period, every man was at liberty to enter at any time into any part of the *King's Field*, and there dig and search for ore, without being accountable to the owners or occupiers of the soil for any damage which might be done to the surface, or even to the growing crops. At present, however, although the ancient custom remains in force, a course more in accordance with the principles of common law is usually held in practice, and in formal decisions; so that the agriculturist is much less frequently annoyed by adventurers in this way than used to be the case formerly. All questions or disputes arising between parties working the King's Field are settled in a mineral court, composed of a jury of twenty-four miners, and a presiding officer, called the *bar-master*, appointed by the sovereign, as duke of Lancaster, or by the lessee of the royalty, who is, at present, the duke of Devonshire.

It is evident that, at the period when the mineral laws were framed, the value of the cultivatable soil was not at all a matter of consideration, as compared with the importance of the treasures embedded below; consequently, every inducement was held out, and facility afforded to adventurers willing to search for ore, as well, it may be presumed, for the sake of the national advantages accruing from this branch of industry, as from the profit derived immediately by the crown from the cope, or duty, payable upon the proceeds of every mine. A person having found a vein of ore, he made certain crosses on the ground, as a mark of temporary possession, and then went and informed the bar-master, who attended, and received a measure, or dish, of ore, the first produce of the mine, as the condition of permitting him to work his *mere*, or measure of twenty-nine yards in length, of the vein: the bar-master at the same

time, taking possession of the next adjoining fourteen and a half yards, or half mere, of the vein for the king. And if the vein seemed promising, it often happened that, at the same time, or soon after, there were various applications by other persons to be admitted, each to free his mere, of twenty-nine yards in length, of the rake-vein in succession. These persons sometimes worked the mere in partnership, and were called groove-fellows, and the condition of their occupancy was, that they should immediately begin and continue to work at their mine; or, in case of intermission for three successive weeks, the bar-master was authorised to dispossess them, and give the mine to another.

As these first mines were all in the districts where the limestone was only covered with a layer of soil, each miner went immediately to work, and having cleared the surface, they with picks, hammers, and steel wedges, loosened the ore and spar, and threw out the stuff with shovels from as great a depth as practicable. They then placed over the excavation a square frame, composed of four narrow planks of wood laid across, and pinned together at the corners; on these two upright posts were erected, with holes or notches to receive the spindles of a rope-barrel for winding up the ore in small tubs: this apparatus, called a *stowse,* being erected on each mine, the sinking was farther continued, and the heaps on the sides of these *open works* increased, until a perpendicular ditch of the width of the vein, and many yards deep, was opened, with proportionally large heaps of rubbish on each side, in some instances for several hundred yards in length, with other similar veins and heaps parallel to and crossing them at certain angles. In process of time, this rude windlass was succeeded by the horse-gin, and various improvements in draining off the water, as well as in working the mines generally, were introduced.

The mining laws which had, previously to the improvements, required a working stowse, and its actual use, at least once in three weeks, in drawing ore on each

mere, now became relaxed, so far as to allow models of stowses, or small *sham* drawing apparatus made of thin laths of wood, which the bar-master provided, to be used as the means of keeping possession of all the meres but one, on a consolidated mine: a custom which prevails at the present day, and is so rigidly enforced, that a mine, on which large steam-engines and powerful horse-gins, and other extensive apparatus, may have long been used, is not held to be legally occupied, unless one of these pigmy memorials of the primitive mode of drawing ore is constantly kept "in the sight of all men," as the law expresses it, on or within a certain distance of the drawing shaft (where a stowse worked by men is not used), and others on each of the meres of ground, or lengths of twenty-nine yards, of which the mine consists.

Mr. Farey, from whose elaborate survey of the mineral district of Derbyshire, many of these particulars are derived, farther observes: — "The laws of the King's Field punish by fines all such persons as are detected in removing or destroying the bar-master's stowses, though placed across the middle of a cultivated field, a common, or on the fence-wall next a public road; but the noble horse, or the sturdy ox, disregarding such puny representatives of property and authority, continually tread them to pieces; while travellers and strangers, the servants of gentlemen who are travelling, in particular, as commonly bear them off from the roads, as curious memorials of the folly and superstition of the inhabitants. The bar-master furnishes such models, which, to be effective, must have no nails used in their structure, but be pinned together with wood, according to the state of actual stowses, when these were first introduced as their representatives; for each of which he charges a small sum, and the miners are obliged to be very particular, at short intervals, to replace all such of their possession stowses as are broken or gone. If a known unoccupied vein crosses the choicest paddock which a farmer has, or even his garden, or the park of a gentleman within the

King's Field, he must take it of the bar-master, by the payment of a dish of ore, and erect these sham stowses, and even a real one, and make periodical attempts, however slight or colourable they may be, to work the vein; or any other person, by application to the bar-master, may dispossess him of such vein, and enter on his lands, and without mercy dig, delve, and make poisonous buddle ponds, ways, and roads therein." The transcriber of the foregoing passage recollects with what surprise, when, on first visiting Mattock as a youth, he noticed and learned the use of a number of these gim-cranks, which, like vermin traps, were stuck about in the shrubbery of R. Arkwright, esq. of Cromford.

The ore, having been detached from the strata in which it is embedded, either by picks, or by means of gunpowder, and brought to the surface as already described, is in the next place dressed by the following process: — each bucket of stuff is sorted into three sorts, viz. knockings, riddlings, and fell, the latter being what passes through an inch iron-wire sieve, in which the riddlings remain: the knockings, which are the larger pieces of spar or stone, most of them with ore intermixed or adhering, are put into a barrow, and wheeled to the bank; the riddlings are emptied into the picker women's wooden hoppers, and the fell is thrown on a heap. The smaller ore is, in the next place, washed, to free it from the loose dirt, in a tub of water, by means of a stout sieve; while the larger pieces are broken small upon a hard stone or cast-iron plate, about seven feet long and seven inches broad, the largest pieces having been previously reduced by means of a sledge or balching hammer. The knockers, who are generally women, having reduced the ore to pieces of about the size of peas, it is transferred to the washers, who are provided each with a large tub or ore-vat, almost filled with water, and an ore-sieve, composed of 58 to 72 wires in 17 inches, which is the diameter of their rims; into which they put a considerable quantity of the pounded ore, which they thoroughly rinse, re-

peatedly throwing out the larger pieces, the smaller matter falling into the vat, while the peasy or granulated ore is dexterously taken from the riddle by means of a small shovel board. Modern improvements in the processes of smelting lead have led to the means of separating the metal from ore, even when in a state of mud or dust, which could not be effected by the ancient method. On this account, not only is the ore at present raised, thoroughly exhausted of its metallic particles, but the refuse of the old workings has been very successfully redressed and turned to account, by an operation called *buddling*, which consists in washing the stuff of the hillocks scattered over the district, in a running stream; a practice, however, which is exceedingly reprehensible as frequently poisoning the water for several miles in its course.

All lead ore which is dressed ready for sale, in the King's Field, is obliged to be measured in presence of the bar-master before it is removed from the mine; for which purpose, in Wirksworth wapentake, a rectangular box is used 28 inches long, 6 wide, and 4 deep, called a dish, and reputed to hold 14 Winchester pints when level full; while in the High Peak hundred, 16 pints are reckoned to the dish. In the measuring of ore, every 25th dish is set aside by the bar-master, as the king's cope or lot; and, in case of a composition being due to soughers, who free the mine of water, as $\frac{1}{6}$th in Wirksworth and of tythe being payable, as $\frac{1}{40}$th in the same place, the bar-master causes every sixth and every fortieth dish which is measured, to be set aside or laid in separate heaps, for the use of the parties, and so of the lord of the manor's dues, if any such are payable where the mine is situated. The tythe of lead ore is said to have been claimed on the groundless pretension that the ore *grew* and renewed itself in the vein. About the year 1780, the gentlemen miners, or maintainers, as they are called, in Wirksworth, met the clergyman, and agreed on $\frac{1}{20}$th as the tythe owner's share of saleable ore from the mines; but the working miners, when they

came to hear of it, all met, and unanimously resolved to pay no more than $\frac{1}{40}$th of their ore as tythe, which the clergyman, much to his credit, accepted, without further dispute; and the same has continued to be the proportion paid in that parish.

As the miners of Derbyshire do not smelt their own ore, it is sold to the owners of the cupalos, or smelting-houses, when dressed as above described, on conditions varying somewhat according to circumstances. The principals of a smelting-house of respectability informed Mr. Farey, in 1810, that their usual practice in buying ore was, to consider 58 lbs. as the standard weight of a 14 pints dish of ore, and to allow the miners to whom they were regular customers, half the price per ton for their ore that lead bore per fother at Hull, at the time of taking up each parcel of ore; and that parcels of ore, weighing less or more than the above standard weight per dish (from the average of three dishes), were deducted for, or allowed extra, at the rate of ten shillings per ton of ore for each pound that the dish fell short of, or exceeded the standard. In such a mode of sale, it was, of course, understood that the bargains were made for considerable periods of time, in order that a fair proportion of rising markets might occur in favour of the smelter as a counterbalance to the falling ones, which are in favour of the miner.

In the earliest periods of the mining in Derbyshire, the ore was undoubtedly smelted on the tops or western brows of high hills, by fires made of charcoal and wood, and blown by the wind only: these ancient hearths were termed boles, and the appellation is still retained by several elevated sites in the neighbourhood of the lead districts. One of these bleak eminences, near Chesterfield, crowned with a fine plantation, and conspicuous to a great distance on the moors, has been charmingly celebrated by Mr. Montgomery, in his well-known stanzas entitled, "Bole Hill Trees." These very ancient boles, or wind hearths, were succeeded by slag-mills, or hearths similar to those at Mendip; being somewhat like a blacksmith's forge on a large scale, and blown

by bellows worked either by men or water, and one of which still remains attached to each cupola, where there is a stream of water, for the convenience of remelting the slag, after the metal has been first drawn from the ore in the draught furnace.

The cupolas, as they are called, or those low-arched reverberating furnaces which are commonly used for smelting the lead ore in Derbyshire, are said to have been introduced from Wales, by a company of Quakers, about the year 1747. The very perfect cupolas of Sykes, Milnes, and Co., called Stanage, in Ashover, are minutely described in their construction and management, by Mr. Farey; the description of this gentleman is, therefore, here adopted: — "Each cupola here consists of a reverberatory furnace about ten feet long, and six feet wide in the middle, inside, and two feet high in the centre; the flame being supplied from a fire-place at the end, over a wall of bricks, called the fire-bridge, one foot high, and reaching within eighteen inches of the roof, which descends gradually to the end opposite the fire-place; where it is only six inches high, and where are two openings, separated by a triangular block of fire-stone, which meet in the passage or flue, eighteen inches wide. This flue curves upwards through a length of ten feet or more, and is covered by flat stones closely joined in fire-clay, that can be removed when the flue-glass, or vitreous scoria, requires cleansing; these flues join by an easy curve into a tall chimney, whose top is fifty-five feet above the ground. One side of the furnace, or cupola, is called the labourer's side; here the door is situate for supplying coals to the fire, and also three small openings, about six inches square, into the furnace, stopped by iron plates, that can be removed when a free current of air is required, or the furnace needs stirring. On the other side, called the working side, are three similar openings, stopped in like manner, by moveable iron plates, and two others below them, for tapping the slag and the lead, as mentioned below; the ash-hole also

opens on this side, and has conveniences for raking and opening the grate-bars from below, in case of their slagging up, so as to impede the draft to the fire.

The floor of the furnace, which is composed of old slag, roughly rounded, and brought to the proper form by hoes, is made up nearly to the level of the small doors on the labourer's side, but declines so as to be eighteen inches below the middle door on the opposite, or working side; and here the tap-hole is situate, for letting out the lead into a large cast-iron pan, called the lead pan, placed under it in a niche in the lower part of the furnace. From the lead tap-hole the bottom rises all ways, forming thereby a receptacle of the proper size for the lead contained in a charge of ore; level with the usual surface of which, another tap-hole is made under the door which is farthest from the fire-place: this is for tapping or letting off the slag. In the centre of the top of the furnace there is a small opening, called the crown-hole, covered by a thick iron plate when the furnace is at work; above this crown-hole is a large hopper of wood, with an iron tube below it, reaching down almost to the plate which covers the crown-hole; above the iron tube the hopper is furnished with a shuttle, or sliding valve, and the whole is suspended by framing from the roof of the large building, like an immense barn, in which four of the cupolas thus described are contained. Into the aforesaid hopper a charge of ore is put, at leisure times during the working of the furnace, ready to be instantly discharged into it, by removing the crown-plate and drawing the hopper-shuttle, as soon as all the lead of the previous charge has been drawn off, and the tapping holes are stopped up by quick-lime, tempered as mortar; so that neither time nor heat is lost between the charges.

In the cupola or furnace thus constructed, the process of roasting the ore at a moderate heat, to expel or sublime the sulphur, arsenic, &c. can be performed, and afterwards an intense heat can be applied for expelling the oxygen or reducing the metal. The ore,

which is here shot down into the furnace at once, usually consists of five or six, or even seven or eight sorts, from different mines, or dressed in a different manner; on which mixtures, in due proportions determined by experiment, the perfection of the process much depends. Sixteen hundred weight (of 120 lbs. each) is the usual charge, which is first raked and spread over the floor of the furnace, and then the doors are closed to bring it to a red heat; when the doors are again opened, and the ore is raked and stirred about, first from one side of the furnace and then from the other, so as to expose repeatedly every part of the ore to the action of the heat and the air, during several hours; at the end of which time the doors are again closed, and the fire increased to an intense degree, by which the reduction of the metal is effected, collecting in the bottom of the furnace, while the slag swims on the top of it, to the depth of two or three inches. The tapping of the slag is then performed, by poking out the stopping of lime, when the slag flows out like melted glass in appearance, and soon cools on the floor of the building; in which state it is opaque, of a whitish-grey colour, and moderately heavy. This macaroni slag, as it is called, being drawn off, the smelter immediately scatters in upon the melted lead two or three shovels-full of quick-lime, in powder; which has the effect of stiffening the remaining slag, which floats on the metal, and which is carefully raked off in a semi-fluid state: this is called drawn slag, and is, when cold, of a very dark or black colour, and very heavy.

The lead-pan being cleared out, and the stopping of lime removed, the metal is suffered to run clean out of the furnace into the pan, which is then skimmed, and the dross is thrown back into the furnace, where it exhibits the most vivid and beautiful changes of colours imaginable; the lead is then taken out by ladles, and poured into seven or more cast-iron moulds with round ends, of the proper size for pieces of lead, which are placed in a row, and are there left to cool. A new

charge of ore is now let down into the furnace, through the crown-hole, and the operations repeated, by means of two sets of workmen, during every seven or eight hours, for the whole week. Coals are used that are a little disposed to cake or crozzle. According to the authority now quoted, 66 *per cent.* was about the average annual produce of metal from the ore smelted at the Stanage cupolas, though some choice parcels had produced 76 *per cent.*

The pieces, or half pigs of lead are not of any certain weight, though the smelter here endeavours, in filling the mould, to approach as near to $176\frac{1}{4}$ lbs. avoirdupois as he can; this being the 16th part of the mill fodder in use in Derbyshire; consisting of $23\frac{1}{2}$ long cwt. (of 120 lbs.), or 2820 lbs., which is the largest of twelve fodders used in different places, to the no small inconvenience of the trade. The Derbyshire lead is weighed at Stockwith, when transhipped from the Chesterfield canal-boats into coasting vessels laying in the Trent, by the fodder of 2408 lbs.; according to which weight the smelter makes up his invoice to the London lead merchant; but, on the arrival of the metal in the Thames, it is re-weighed by the fodder of 2184 lbs.; or, if consigned to the Hull market, it is there re-weighed by the fodder of 2340 lbs.; and yet the custom duties are payable on the fodder of 2240 lbs. The slag lead, or that which is drawn by means of the bellows from a re-smelting of the drawn slag before mentioned, is much harder and more sonorous than the furnace lead made in the cupolas; and, in order to distinguish the sorts, the pieces of slag lead are cast in moulds with square ends instead of round, as those used for the soft lead have. For making minium, common shot, and various other uses, the hard or slag lead is preferred.

In consequence chiefly of the discovery and successful working of extensive and rich lead mines in Spain, the foreign markets have, for some years, been largely supplied from that quarter: complaints, however, on this score, were heard as early as about the year 1765;

but since then the Spanish have been much more extensively sought; so that our export trade in this metal has sadly fallen off, and the miners in every part of the country have suffered extremely from this cause. As the admission into this country of foreign lead at a small duty is allowed, the depression of the trade has frequently been attributed solely to that circumstance by ignorant or interested men, when they have found occasion to inveigh against what is called "free trade;" with how little reason, will be seen from the following account of the quantity of lead, lead ore, &c., exported and imported in the years ending January 5.: —

Years.	Foreign Lead imported.	Foreign Lead exported.	Foreign Lead admitted to Home Consumption.	British Lead exported.
	Tons.	Tons.	Tons.	Tons.
1821	4	4		19,772
1822	275	0		17,460
1823	883	81		15,830
1824	546	307		12,940
1825	903	749		12,991
1826	7766	3655	1372	10,560
1827	2033	1847	15	12,409
1828	3240	2282	16	16,217
1829	7466	1785	122	13,256
1830	1708	1700	35	8,647
1831	1016	861	45	9,309

From this it appears that the whole of the foreign lead brought into home consumption, since the free trade acts came into operation, amounts to no more than 1605 tons, of which 1372 tons were in the first year; so that the average quantity for the last five years has only been 47 *tons per annum*. It will be seen also, that the export of British lead has fallen off nearly one half since 1821; so that it is obvious the Spanish mines have chiefly interfered with those of Great Britain by driving us out of the foreign market, and not by underselling us at home. The returns for the year ending

January 5. 1833, are as follows: — lead and lead ore imported into the United Kingdom, 1386 tons, 18 cwt. 1 qr. 14 lbs.; of this quantity something more than 269 tons consisted of ore from the Isle of Man, and 59 tons of pig lead from Gibraltar. The total export of British lead during the same time was, 13,898 tons, 3 cwt. 3 qrs. 6 lbs., exclusive of 956 tons, 15 cwt. 3 qrs. 19 lbs. of the foreign lead which was also exported. Thus indicating a considerable improvement in the trade as compared with the year preceding.

The price of lead in the home market has fluctuated considerably: in 1806, it was *35l. 12s. 6d.* per ton; exactly ten years afterwards, it was only *16l. 5s.*; and although it afterwards rose, and for some years maintained an advance of about five *per cent.* upon the price last mentioned, in 1829, it had fallen to *14l. 5s.*; and in that and the following years the poor lead miners suffered great distress in every part of the kingdom. With one district the present writer became more immediately acquainted; and, in consequence of having at that time the means of appealing to the public sympathy through an influential public journal, he had the satisfaction of being the medium of several small but beneficial pecuniary donations to the patiently suffering miners.

CHAP. IV.

MANUFACTURED LEAD.

PREPARATION OF LEAD FOR THE PLUMBER. — QUANTITIES CONSUMED FOR DIFFERENT PURPOSES. — ANGLO-SAXONS COVERED BUILDINGS WITH LEAD. — EARLY NOTICES OF LEADEN COFFINS. — CASTING AND ROLLING SHEET LEAD. — SIZES AND QUALITY. — CHINESE METHOD OF CASTING SHEET LEAD. — DIFFERENT KINDS OF SEAMS IN JOINING THE METAL. — ANTIQUITY OF LEAD PIPES. — CONDUITS AT HAMPTON PALACE. — CASTING, DRAWING, AND ROLLING PIPES. — PUMPS. — FIRE-ENGINE. — BEER MACHINE. — WATER CLOSET. — LEAD SPOUTING. — SOLDERING. — LEADEN WINDOWS. — DOMESTIC UTENSILS RARELY MADE OF TIN. — DEVONSHIRE COLIC. — SHOT. — CASTING BULLETS. — BOSWELL'S SPHERICAL BULLETS. — WATTS OF BRISTOL. — SHOT TOWER. — GRANULATION OF SHOT.

The diversity of uses to which lead is applied, in the ordinary arts and manufactures of this country, is by far too great to admit even of enumeration: in order to prepare the metal for these various purposes, the pig is reduced either by casting, rolling, or some other means. Probably the greater portion of the whole amount consumed in this country, by the plumber, is in the state of sheets; these having been formed, either by simply casting them, according to a process presently to be described, or by first casting, and then passing the metal between large steel rollers, by means of which the sheets are not only reduced to any degree of thinness required, but are thereby rendered uniform in their substance throughout, as well as perfectly smooth on the surface: this latter is called in commerce milled lead. Of sheet, or milled lead, the quantity used in the covering of buildings, and for the formation of pipes of all sorts and sizes, is prodigious; what this amount may actually be, or whether, on a comparison of past times with the present, the consumption would, all things considered, be found to have diminished or

increased, we have not the means of ascertaining correctly; it is reasonable, however, to suppose that the balance must be vastly in favour of the latter. Although in mansions and public buildings of a certain class light slates may have been of late adopted in the covering of roofs, which would, at another period, have been overlaid with sheet lead, yet, when the exceedingly great number of buildings in the completion of which eaves, gutters, and all the requisite overlappings of this metal are required, are taken into the account, a great deal more lead must needs be consumed by modern plumbers than might suffice for like purposes in former times. In the article of piping, whether for house spouts, or underground conduits, the use of lead has been largely superseded of late by the elegant and economical application of cast-iron; while, in the construction of pumps for ordinary purposes, bored timber has, in a great measure, given way to leaden tubes, to say nothing of the large amount of the latter required for a variety of hydraulic engines, comparatively of recent invention.

The Saxons, in the earlier period of their history, covered their buildings with slate; but, according to Strutt, their most magnificent structures were overlaid with lead; Ingulphus says, the abbot Terketulus, in the time of king Edgar, added large buildings to the monastery of Croyland, for the reception of poor monks: —"Omnia de lignis levigatis facta sunt (quia molam lapideam fundamentum debile ferre non suffecit) *plumbaque cooperata.*"

Lead, in the condition of sheets, has long been applied in this country for the preservation of the dead bodies of great personages: this practice, seemingly unknown during the Saxon and Norman reigns, began to be prevalent in the English era. Geoffrey Mandeville, in the reign of Henry I., dying under the curse of excommunication, might not be buried in consecrated earth; therefore some of the knights templars, says Camden, enclosed him in a pipe of lead, and hung him upon a

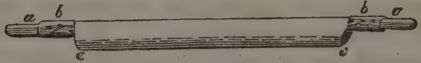
tree in an orchard at the old temple. Weever does not call it "a pipe of lead," but "a leaded coffin." This singular circumstance, however, is not by itself thought sufficient to warrant a conclusion, that the practice of so enclosing the corps obtained at so early a period in cases of actual interment; Edward the Black Prince being dead, his body, says Froissart, was "*embasmé et mis en ung vaisseau de ploncq*"—embalmed and put in a vessel of lead. And the corps of his successor, Richard II., was, as we are told by Harding, "lapped in lede;" and so afterwards were the mortal remains of the monarchs of this country, as well as many great men disposed of previous to burial. In our own times, the practice obtains among the more respectable classes generally; the soldering up the body in this manner not only preserves it from all access of air, and consequently from decay, through an indefinite period after it is deposited in the tomb, but it affords opportunities for that delay between disease and interment which, but for this expedient, could hardly be secured except by embalming or other like offensive process.

The sheet lead of which coffins are made is generally about one eighth of an inch in thickness, sometimes more, according to order. The leaden coffin, which itself encloses a light wooden shell, is made as nearly as possible in the shape of the outer coffin, within which it is always placed, the lid being finally soldered down with the heated iron.

Sheet lead, adapted for the above-mentioned, and innumerable other purposes, is prepared, as already stated, by casting and rolling; the former process being that which, in connection with hammering, was exclusively known to and practised by the old plumbers: the latter method has originated in the obvious and easy application of the immense power of the modern flatting mill. In casting sheets of lead, the operation is as follows:—A stout table or bench is provided, measuring about five feet in width, and being from fifteen to twenty feet long; this is surrounded by a

raised margin of board, four or five inches deep in the inside, and the parallel sides planed, so as to incline very gently from the top of the table to the bottom; upon this table is spread a covering of fine river sand, sifted to free it from lumps and other matters, and pounded, along with a little water, so as to make it cohere when beaten on the surface. The sand, in this state, being shovelled upon the bed, two workmen, taking hold of each end, *a a*, of a wooden strike of the subjoined form, and walking on opposite sides of

Fig. 4.



the table, draw or slide the billet over the sand, in such manner as to lay its surface even through the length of the bed. It must be understood that the rounded surface of the strike from *c* to *c* extends within the upright sides, the parts at *b b* sliding along the superior edges; the sand-bed being thus levelled, a planer, made of copper, and having a handle resembling a plasterer's trowel, is dexterously applied all over the surface of the sand, in order to render it as compact and smooth as possible.

The bed being thus prepared, the next operation is the covering it with metal; for this purpose the lead is ladled out of the large cast-iron pot, in which the pig has been melted, and which, for conveniency, is near the head of the table, into an oblong trough of metal or wood,—if of the latter material, lined with sand,—and suspended by tackle at the head of the casting-table. This vessel, when charged with a quantity of metal equal to the weight of the contemplated sheet, is drawn up to the height of the table, and its contents upset on the sand. The two men then being ready with the afore-mentioned strike, place it across the table, resting it upon the raised edges, and, passing quickly along, they spread out and drive forward the molten metal, so as to leave behind them a plate of uniform thickness to cool upon the sand, the overplus of lead flowing off

at the foot of the table into a box placed there to receive it. The thickness of the metallic sheet is regulated by wrapping, and fastening with nails, pieces of leather about the sliding places of the strike at *b b*, and which, by elevating the lower face from *c* to *c*, leaves the mass of fluid metal correspondingly greater on the sand. It need scarcely be remarked, that the success of this operation depends a good deal upon the adroitness with which it is performed, as well as upon the goodness of the metal used. The best kind of lead runs with an easy fluidity, and appears, when cast, light-coloured and uniform on the surface; while a harder and inferior description does not spread freely, and presents blue or prismatic colours, in some places very deep, but more or less diffused over the whole body. The lead in this state is denominated among plumbers by terms indicative of the weight of a square foot, as 5, 5½, 6, 6½, 7, 7½, 8, 8½ lbs. It is this cast lead with which buildings are, or generally ought to be, covered, being considered to be less liable to contraction and expansion, and consequent fracture from change of temperature, than milled or rolled lead; though it is probable the difference between the two sorts, in this respect, depends less upon any peculiarity in the manufacture, than upon the advantage which the original quality and greater thickness of the cast gives it over the milled metal,—the latter being of a mixed and inferior material, as well as that it is occasionally used very thin. Lead is sometimes rolled into sheets about six feet in width—the length depending upon the thickness; a sheet weighs 9 cwt. Mills for reducing lead into sheets by means of immense rollers and steam power are generally found in the mining districts; there are celebrated establishments of this kind in Derby, and also at Newcastle-upon-Tyne.

The Chinese, in manufacturing the thin sheet lead in which their teas are imported into this country, conduct the operation in an exceedingly simple manner. The laminæ are not rolled, as from their extreme thin-

ness might be supposed; nor even hammered, as the appearance of the surface might indicate; but actually cast at once in the state in which we see them. Two men are employed: one of them is seated on the floor, with a large flat stone before him, and with a moveable flat stone-stand at his side. His fellow-workman stands beside him with a crucible containing the melted lead; and having poured a sufficient quantity on the slab, the other lifts the moveable stone, and placing it suddenly on the fluid lead, presses it out into a flat and thin plate, which he instantly removes from the stone. A second quantity of lead is poured on in a similar manner, and a similar plate formed; the process being carried on with singular rapidity. The rough edges of the plates are then cut off, and they are afterwards soldered together for use. Mr. Waddell, a Scotchman, who witnessed the operation in China, applied a similar method, with great success, in the formation of thin plates of zinc for galvanic purposes.

In laying sheet lead upon roofs, it is necessary to join the pieces together, as well to secure them against being blown off, as to prevent the entrance of rain or snow into the buildings so overlaid. There are three kinds of seams, described by plumbers as rolls, overlaps, and soldered. The former, and that which is accounted the best, consists in placing pieces of wood, about two inches in the square, but rounded on the upper side, at convenient intervals upon the boards with which a roof is usually first covered; and after the edge of one sheet has been folded over the wood, the adjoining sheet is folded over that, in the opposite direction, somewhat in the manner in which tiles are seen to roll over one another at the sides. The lead, in this case, is fastened only by being closely hammered down; the pieces lying very close, and the elevation of the roll preventing the water from passing through, unless under very extraordinary circumstances. Overlap seams are made by merely bending up the two edges of the lead as they adjoin, and then folding them closely over each other, and ham-

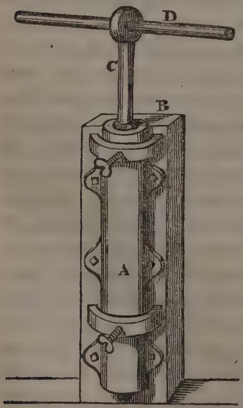
mering them well down. Both these methods admit, in different degrees, of the expansion of the metal; which is not the case with the third sort, or soldered seams, and which are most rarely adopted in roofing. In the making of pipes, and lining of cisterns, where, on many account, sudden and extreme variations of temperature are less to be anticipated, soldering is always resorted to. The tools of the plumber are few and simple: hammers, wooden mallets, the dresser and flattener, which is an instrument about twenty inches long, made of beech-wood, flat on one side, and rounded on the other,—the former suited for spreading out the lead, the latter for laying it in gutters; grozing or soldering irons for making seams; a stout knife for cutting the sheets with the assistance of a hammer; and planes, similar to those used by the joiner, for the purpose of smoothing the edges of work in which neatness is required.

Valuable as lead is for a variety of purposes in a laminated form, its use, when wrought into pipes, is still greater. The use of lead tubes for conveying water and other fluids is of great antiquity — the Greeks and Romans having employed them for many of the purposes for which they are used in modern times, especially as conduits for fountains: many remains of this practice have been discovered at Herculaneum. In the orifices of several of the antique figures in the British Museum, bits of lead piping still remain, as indicative of the original destination of the sculptures. In England, where mines of this metal abounded, its value for such purposes was discovered many centuries ago. So early as 1236, pipes were laid to bring water from Tyburn to the city of London; but of what material these were made, we are not told. Stow, however, mentions that, fifty years afterward, namely, in 1285, water was brought from Paddington to Cheapside in leaden pipes laid under ground. A striking illustration of the expenditure of lead for conduit pipes at a later period, occurs in the instance of Hampton Court Palace, which is supplied with water from some springs

in Coombe Wood. The distance, according to Mr. Jessie, is two miles in the most direct line; and the leaden pipes which convey the water, are carried across the bottom of the Thames. There are two pipes from each conduit, making altogether eight miles of leaden pipes. These pipes were laid down by cardinal Wolsey, for the purpose of supplying his palace with water. A foot of this old lead weighs twenty-four pounds; and, allowing one pound for waste since the time of the cardinal, each pipe must have weighed 132,000 lbs.; and the eight, therefore, 1,056,000 lbs. It may be added, that the palace itself (which was, probably, considerably larger in Wolsey's time) is covered with lead.

Lead pipes are made, either by casting, and afterwards drawing or rolling the metal upon a mandrel; or by bending flatted pieces, cut to the requisite size, until the edges meet over an iron or wooden model, so as to form a proper suture, which is afterwards soldered. The latter is usually the method adopted in the manufacture of light wide piping, in which great smoothness or exactness of calibre is not required. The

Fig. 5.



casting-box consists of an iron cylinder, A, *fig.* 5., made perfectly smooth inside to the size of the intended pipe: it is also made to open longitudinally — one of the parts having flanges, or ears, by means of which it is fastened to an upright post, B; the other, or removeable half of the cylinder, is maintained in its proper position for use, by means of collars, wedges, or screws, such as are generally applied for the closing of casting boxes. A very accurately turned steel mandrel, C, answering to bore of the pipe, and finished at the top with a

stout fixed ring, is put down the cylinder, the lower end resting in a centre hole, and the upper part having a neck, or collar, to keep it equidistant from the cylinder. The lead being poured in at the upper orifice, and filling the mould, a tube is formed upon the mandrel, which is withdrawn, without difficulty, by putting a stout spanner, D, through the ring, and turning it round; after which, the mould is opened, and the casting taken out. In casting large heavy pipes, the mould is placed in an inclined, or nearly horizontal position; and the inside model, or iron mandrel, is withdrawn by means of powerful machinery. Having been thus cast in lengths, the pieces of piping are put in succession upon another mandrel, much longer than the first; they are then passed between rollers having grooves of different sizes according to the external diameter required, or they are drawn through metal wortles or collars of different dimensions upon the said mandrel — each succeeding collar being less than the former — until the lead be extended to the length and thickness required. The latter operation, if the pipes be large, requires great power in the performance of it, and it is usually done by the steam-engine — the wheel and pinion train between the prime mover and the chain, or rack, of the drawing bench, admitting of being detached the moment the pipe has passed through the wortle. An objection has been raised to drawn pipes, on the ground that the stretching to which they are subject must needs enlarge any flaw occasioned by casting; while, on the other hand, the elongation of the pipes by rolling has rather a tendency to close up, by a compression of the substance, any such original defect. Imperfections may, undoubtedly, be met with occasionally in both sorts; but it is easy to submit them to careful examination or to satisfactory proof before they leave the manufactory; and this being done, the large amount of the article, and the fewness of complaints in the market, furnish the best ground for concluding that drawn or rolled pipes, when well made, are, equally with cast ones, adapted to their proper purposes.

The construction of the various sorts of pumps, and of hydraulic machines in general, into the manufacture of which lead and brass chiefly enter, is an important part of the business of the plumber. A detailed explanation of the principles upon which these machines act would be out of place, especially as a previous volume of this work is devoted exclusively to the subject.* A few remarks on the external mechanism of some of the articles alluded to, belong, however, to the present chapter. Of pumps there is a variety of different constructions; and these, as to principle, are generally divided by writers on hydrostatics into lifting pumps, sucking pumps, and forcing pumps: but these terms by no means include every description; and, in some, these principles of operation are themselves combined. Although, in ordinary situations and for common purposes, the old-fashioned wooden sucking pump is by no means uncommon; yet, under other circumstances, the use of metal has very extensively obtained of late years. In articles of this description, as requiring a valve or sucker to work in the barrel, the latter part may be made of cast iron or brass, carefully bored, and united to the lead suction pipe by a union joint, or by soldering, the brazen piece having been previously well tinned at the end by immersion in hot liquid metal. This part is sometimes merely a stout tube of copper, drawn upon a triblet, and inserted withinside the leaden barrel, as a sort of lining in which the bucket or piston may freely work. There are two descriptions of valves commonly in use among pump makers: first, the old clack, consisting of a small lid, or cover, opening and shutting over the orifice in the piston, in the manner of a trap-door; and, second, the stopper valve, which is a circular disc of metal bevelled on the under edge, and ground to fit the hole of the piston, which is bevelled to receive it; the centre contains a stem fitted through a hole in a cross piece above and below, so as to play freely up and down. The former kind of valve, it will be per-

* Cab. Cyclo. HYDROSTATICS AND PNEUMATICS.

ceived, must open obliquely, the water rushing through on one side; the latter rises vertically, the water entering all around it.

Fig. 6.

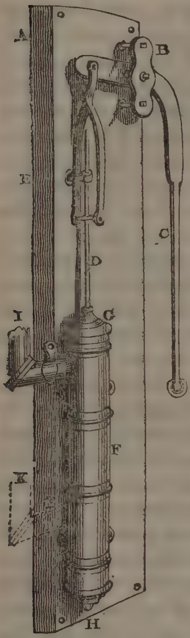


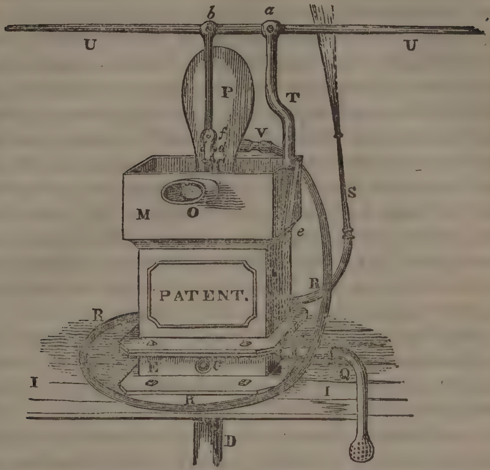
Fig. 6. represents an ordinary forcing pump, the parts not being boxed up. A, a stout plank, which may be fixed against a wall or other support. B, the fulcrum, or projecting prop, the middle pin of which is the axis of the lever handle C, bent at the upper end, and usually made of iron. D, the spear, or bucket rod, having at its lower end a piston, with a valve opening upwards; the top end of this rod passes through a hole in the projecting bracket E, so that its ascending and descending stroke is perfectly vertical; this motion is allowed by means of the diagonal action of the gearing connecting it with the handle C, and which resembles that applied to some steam engines for the regulation of the descent of the piston in the cylinder. In the old wooden sucking pumps, where the bucket spear is often not only flexible, but of considerable length, and where no nicety of operation is required, the upper end of the handle is pinned immediately to the top of the rod; the amount of deviation from the plumb-line, which takes place during the progress of the connected lever through a given arc at every stroke, being distributed through the length of the rod so as not to affect the sufficient action of the bucket. In all the better sorts of pumps, however, the more scientific contrivance above described is mostly applied. F is the barrel or working cylinder, made of cast iron, to which is soldered brass mountings

for screws, &c. The upper end is terminated by a well packed stuffing box, G, through which the piston rod works. The lower end, H, is finished with what the plumbers term a union joint, for the introduction of a valve opening upwards, as well as for the affixing of the leaden suction pipe that goes to the water. This barrel is attached firmly to the plank by screws passing through side ears on the casting; it should be bored and fixed very accurately, in order that the stroke of the rod may be exactly perpendicular. I is the side pipe, fitted with a stop-cock, between which and the barrel there is a valve opening outwards; to this pipe is attached the service pipe, through which the water is raised to any elevation above the pump.

From the foregoing description, it will be obvious that the impulse by which the water is driven through the pipe I is communicated from the upper side of the piston when the valve is closed, the stuffing box at the same time being sufficiently tight not to allow any water to escape while under such powerful pressure. It is, however, to the application of a somewhat different principle, or rather different construction of the machine, to which scientific writers sometimes confine the appellation of forcing pump. If the stuffing box G be removed altogether, and the side pipe I be placed lower down, in the situation shown by the dotted lines at K; and if for the valved piston an entirely solid one be substituted, the engine will be altered into a forcing pump, more exactly answering to the technical application of the term. In this latter arrangement, it will be observed that the under side of the piston alone is used, as well in raising the water through the suction pipe, as in afterwards driving it to the required distance or elevation through the side pipe. The common fire engine consists of two of these forcing pumps made to act alternately, their suction pipes adapted to a common reservoir, and the lateral vents of both opening into a hemispherical air vessel, to which the service pipe of the hose is attached.

Fig. 7. is a representation of a machine combining

Fig. 7.



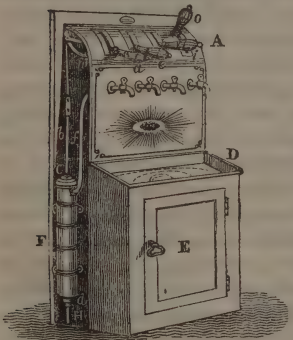
the efficient utility of the sucking pump, the forcing pump, the siphon, and the fire engine. It is the invention of Mr. Todd, of Hull, and for which he obtained a patent at the latter end of 1832. This apparently useful hydraulic machine is thus described by the inventor. The main part of the apparatus consists of three separate pipes, which are joined together by means of flanches and screws; or they may be cast in one piece of iron or brass, being, in this case, divided from each other by a partition. The middle one is the working barrel, which is six inches' diameter inside, is accurately bored, and forms a communication with side pipes, viz. one at its top, and the other at its bottom end. This working barrel or chamber is closed by a reversed stuffing box on its upper end, which stuffing box is always covered with water to the height of five or six inches, which most effectually prevents the admission of air to the apparatus. In this cylinder works a piston, the copper rod of which, C, is represented at half the up-

stroke. At the top and bottom of each of the side pipes, valves are fixed, opening upwards into one channel or receiver. D is the main suction pipe to the water; and E the chest or box with which it communicates. G, the place of a stop-cock for shutting off the main suction pipe and siphon, when fixed on board ship, but is not wanted for land purposes. H, a brass screw, to which is affixed the suction pipe Q, when wanted for a fire engine; the bent part is placed over the gunwale of a ship; these pipes may be multiplied if desirable, each having its appropriate stop-cock. I I shows the deck of a ship, or ground-line, upon which the pump is fixed. M, the cistern, from which all the water is discharged by the spout O, when acting as a pump for common purposes. P is a copper air vessel, which is screwed upon the cistern just behind the main cylinder when the apparatus is intended to act as a fire engine. R R R shows the leather or canvass hose for the fire engine, attached to the air vessel at V, and to which the copper branch or spouting-pipe S is screwed for throwing a large stream of water. T is a strong iron standard, well fitted into a socket at the end of the cistern, and can be taken away at pleasure when not wanted. U U, the double lever, or handle, about seven feet in length, for working the machine, with its joints and shackles, *a*, *b*, *f*, which, together with the standard T, are all taken away when not wanted, by drawing out the forelock of the socket at *d*, and at the bottom of the standard at *e*. According to the inventor, this hydraulic machine, which is an improvement upon a pump for which he obtained a patent in 1797, may, from the very simple mode of effecting its combinations, with little trouble at any time, or under any circumstances, in one minute, be converted from its most obvious use (as a pump for common purposes) into a double pump, discharging or raising water, both by the ascent and descent of a single piston; thus discharging the same quantity of water as any other common pump of the same size with the same labour. It can also, the maker states, in one minute, with the greatest ease, be converted into a most effective

engine for extinguishing fire, or into a most complete siphon of very great power, or for raising water to great heights from deep wells, &c. Possessing these properties, it is said to be invaluable on board ships, from the ease with which it works, and the quantity of water it discharges; and in all cases of fire at sea, the vessel may be filled with water, by the self-action of the siphon, to any height, in a few minutes; while, at the very sam moment, the engine, with only the exertions of two men, may be throwing a very constant and powerful stream of water on the upper part of the ship or cargo, and by this means many valuable lives, ships, and cargoes may be preserved.

The principle of the forcing pump has for several years past been applied to the raising of malt liquor from the casks in the publican's cellar, and delivering it by a tap in the bar-room. This convenient apparatus, for which Mr. Bramah had originally a patent, consists exteriorly of a neat mahogany case, generally of the annexed form, *fig.* 8. with its back fastened to the wall; about eighteen inches wide, if containing four "pulls," or pumps, or wider in proportion to any additional number. The upper part, A, is curved outward, being a quarter of a cylindrical tube placed horizontally, with apertures cut across and faced with metal, for the working of the levers *a, e, i, o.* These levers are quadrant-shaped within the box, and work upon pins, as shown at *w.* Immediately below each handle a tap projects, under which the measure is held while the liquor is pumped up; any accidental overflow being caught by the perforated block tin receiver D, and suffered to run

Fig. 8.



through into a vessel placed underneath in the closet E. The working barrels are of brass, $2\frac{1}{2}$ inches in the bore, about 8 inches long, and attached by four ears to the back of the chest. In the cut, the chest being represented with the end removed, shows the position of the outer barrel, F. To the rod *b* is affixed the "bucket," or sliding valve, which opens upwards, as does also another valve at *d*. The top of the barrel at *c* is closed with a stuffing box, through which the rod *b* works; so that on raising the rod by depressing the handle, the liquor, being prevented from passing out at the top, is forced up the side pipe *f*, and issues at the tap. H shows the upper end of the suction pipe, attached to the bottom of the working cylinder by a union joint; this pipe, which is commonly of lead, half-inch bore, and sometimes tinned inside, passes through the floor to the cellar, and being left long enough to admit of adaptation to different distances, is attached either to the tap of the cask, or, by means of a brass end piece, is inserted at once into the usual tap-hole. These machines are exceedingly convenient to publicans, not only by superseding the necessity of going down to the cellar for every measure of liquor required, but also by enabling any person in the bar to fill with ease, or oversee the filling of every pot delivered; these advantages, added to the comparative inexpensiveness of the ordinary beer engine, have led to its adoption in almost every considerable tavern in the kingdom.

An important branch of the business of the plumber is the construction or erection of water-closets. Indispensable as these conveniencies are now considered in the arrangement of every well-fitted dwelling house, they are of comparatively recent introduction; nor was it until that extremely simple but useful contrivance — the water-lute — was applied to them, that they were rendered unobjectionable, by the removal of one of the greatest defects which could possibly attach to an article still, in a great measure, peculiar to this country. The principle of this improvement was afterwards ingeniously carried out by the late Mr. Bramah to a much greater

degree of perfection; and his water-closets have been largely in demand in the better sort of mansions; though it has been observed, that, from the nature of their structure, their operation is liable to be impeded by slight causes affecting the passage of the water through the pipes. Tyler's revolving surface valve water-closet is an ingenious contrivance; it is made to open and close by working backwards and forwards a lever handle attached to a small shaft, to which also a rack is secured in a proper position. Mr. Jordan, of Norwich, had a patent for a self-acting water-closet, which has been found to answer completely; but its action depends upon a peculiar movement of one part of the closet, in consequence of which persons may be expected to become with difficulty reconciled to its use.

Fig. 9.

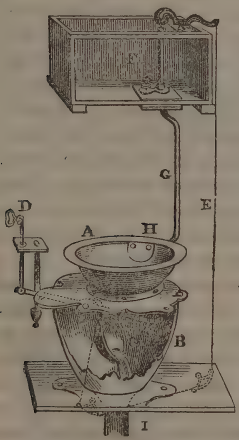


Fig. 9. represents the ordinary improved water-closet, as most frequently constructed; the parts are shown *in situ*, but the boarded covering is removed. A, the basin of earthenware, attached by its lower flange to the cover of the cast-iron pan B, which is in the form of a truncated cone, and a section only of which is shown in the engraving for the purpose of exhibiting the dish C, which, being riveted to a horizontal axis, its position, when at rest, is immediately under the opening in the basin A. By raising the handle D so as to act upon the cross lever, and through it, by means of two cranks, upon the wire E, a valve at the bottom of the cistern F is opened, the water from which falls down the pipe G, and issuing under the plate H, is spread over the inside of the basin, whence it falls into the dish C, which by

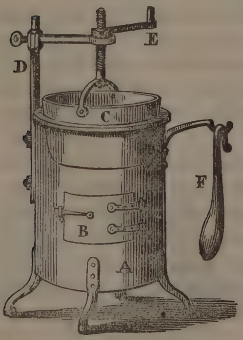
the same movement is depressed, as shown in the cut, emptying its contents through the bottom of the pan and by the main pipe I into the common sewer. The cistern F, which is commonly made of lead, and placed at a considerable height above the other parts, may either be filled from the roof-spouts, or by means of a forcing pump, placed in some convenient situation either in the kitchen or elsewhere. Although, in the construction of water-closets and of hydraulic engines in general, many of the parts are of brass or of cast iron, yet, on account of the quantity of lead piping and cisterns commonly required, and especially the fitting and soldering of joints, &c., their erection is invariably accounted a part of the business of the plumber.

The descending spouts for conveying the rain water from the tops of buildings, and called socket pipes, are generally made of milled lead, and soldered up the back; or rather, this seam, in fixing them, is turned towards the wall, so that they have a uniformly smooth appearance. At distances of from six to ten feet are generally placed short cylindrical pieces of greater strength, with which the upper and lower lengths are connected, and which are furnished with turn-back flaps called tacks, being square pieces of lead by means of which the spouting is nailed to the wall, and thus sustained in its position; upon these cylinders, as well as upon the little cistern at the top of the spout, the plumber frequently places dates, initials, masks, or other ornaments, which are very easily cast in metal so tractable as lead. Inscriptions of considerable length are sometimes cast in relief upon the sheets with which churches or other public buildings are overlaid.

The joining of pieces of lead piping together, or to a cistern, is performed in the following manner: — The parts, where the junction is to be effected, having been made bright and clean by means of a scraper, and then rubbed with a little tallow, are brought together, and held or fastened in the position most convenient for soldering: the plumber takes in a small ladle a portion

of melted metal, composed of three fourths tin and one fourth lead, and pours it upon the part where the joining is to take place, at the same time holding under it a pad made of ticking, to prevent the liquid solder, as much as possible, from falling to the ground. This operation is repeated several times, before the lead becomes sufficiently heated to cause the solder to take: in order to facilitate the effect, the workman keeps constantly patting and moving about the semifluid metal by means of the pad; in doing which, considerable dexterity is required, not only to keep the solder upon the joint, but to prevent the hand of the operator from being burnt. When adhesion begins to take place, it is facilitated and completed by the application of the heated soldering iron, or grozing iron as it called; a collar or swelling of the solder is generally left upon the pipe, where the joining has taken place, to give strength and effect. The instrument generally used in soldering, by the plumber, differs from that mostly in use by the brazier, both in the shape and the material; for, instead of the bit being a piece of copper with a lozenge point, it is of iron, and nearly egg-shaped, having a handle, with a crook at the end, of the same metal. In soldering pipes when laid in the ground, or in other situations in which it is difficult to see the under side, a small mirror is used, which being held below the work, enables the operator to perceive when the soldering is complete.

Fig. 10.



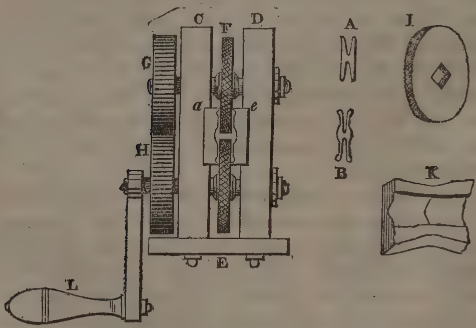
As a good deal of plumber's work has to be performed out of doors, such as the laying and repairing of pipes for the conveyance of water or gas, it is common to have a portable furnace of the annexed figure and description.

Fig. 10. A, is a strong cylinder of cast or rolled iron,

having a grate at the bottom, and a door, B, in the side for the introduction of fuel. C, a cast-iron pot containing lead or solder, is suspended, by means of a screwed rod, to the standard D, and may be raised or lowered over the fire by the operation of the handle E upon the screwed rod. F shows the shape of the soldering iron.

Windows, in which the glass was secured by the plumber's art, were, formerly, very common in this country, not only in the poorer sort of dwellings, but in mansions and churches: the glass was sometimes very thick, of a dull green colour, and usually cut into panes of a rhomboidal figure. This method has been a good deal practised of late in glazing the windows of the churches erected under the directions of his majesty's commissioners. Window lead is drawn in a machine called the plumber's vice, and, probably, derived originally from Germany: a front view of it is shown in *fig.* 11. The lead is first cast into strings or canes, as

Fig. 11.



they are called, having a rebate or groove on both sides, as shown in the section A. These canes are reduced by passing them between two cutters, or edged rollers, made to work nearly in contact, and within a pair of

cheeks affixed in the iron-head or vice; B is a section of the finished lead, as it comes out in a long light slip fit for use. The vice consists of two upright sides of iron, C D, about six inches high, and attached to the bottom plate E, which is firmly screwed to the work bench; F is the uppermost of the two circular steel cutters, about the thickness of a halfpenny, and milled on their peripheries, that they may the better take hold of the lead: they have square holes in the centre adapted to two axles, upon the ends of which are fixed the cog-wheels G and H. The edges of the cutters work nearly in contact, and their sides are confined between the steel dies *a e*, fixed in the inner sides of the uprights, and hollowed in one direction, so as to give to the lead the figure shown in the section B. Separate views of the cutter and die are shown by I K. It will at once be seen that, by inserting the end of one of the canes of lead, and turning the handle L, the metal will be caught by the cutters, and being, at the same time, drawn between the steel dies, must be protruded on the other side in a state fit for use. The small strings of lead which are soldered to the strips after enclosing the glass, for the purpose of being folded upon the stanchion bars, to give stability to the window, are also drawn in the same machine, by means of cutters and dies adapted to the purpose. None but the very best lead can be successfully passed through these operations.

Lead, although fabricated into the vessels used in various arts and manufactures, is not proper for utensils of domestic use; and disastrous effects have sometimes followed its incautious introduction for the latter purpose. A disorder, formerly well known in this country, and called, from the county where it was most prevalent, "Devonshire colic," was shown by sir George Baker, in some papers published in the Philosophical Transactions, to be occasioned by the drinking of cyder in which lead was dissolved: the malic acid of the apple-juice exerts a powerful chemical action upon

the metal, thereby forming the malate of lead, which is a strong poison. In consequence of the evils which have occurred, and the promulgation of a knowledge of their cause, dishes or beds of lead for cyder presses have generally fallen into disuse. The reprehensible use of lead vessels in dairies is not altogether discontinued, though it is well known that when the milk turns to acidity, in any considerable degree, it inevitably absorbs some portion of the metal.

Lead may be plated with tin; but this method is rarely, if at all, practised by manufacturers.

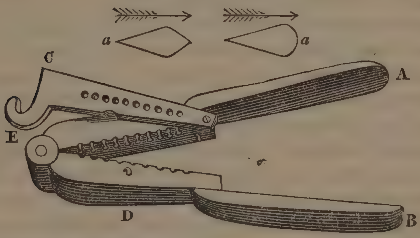
SHOT.

Large quantities of lead are used in this country in the manufacture of shot and bullets, so distinguished as the spherical masses are small or large. There are three convenient methods of producing shot — rolling, casting, and granulation: the first is but little resorted to in the sense here intended; the second operation is that by means of which the most perfect bullets are generally obtained; and the third, is that by which the shot of commerce is produced. If lead be drawn out into square strips or wire, and then be cut up, by means of a knife, or by any other instrument, into little cubical sections, these may be placed, several scores together, between two flat stones, the undermost one lying firm, and the upper one admitting of being moved about in every direction, and thus rolled into perfect shot. To secure exact sphericity, the stone must be moved in a sort of epicycloidal curve; for if it be advanced in right lines, or were merely spun round, the shot would have a cylindrical figure: iron plates, or polished stones, may be used to give to the shot a smoother and brighter appearance. It was by a method analogous to the foregoing, that small shot was originally manufactured: cubes of lead may likewise have an imperfect spherical form given to them by shaking them together. We recollect this method being once turned to ingenious

account by two country forgemen, who were in the habit of shooting great numbers of the wild ducks which frequented the mill dam: the men used, in the first place, to cut up the lead into angular bits of the desired size; these they put into an oblong can of sheet-iron, which they fastened to the head of the forge hammer; the latter, by its motion, violently shook the contents of the can up and down, until the bits within, striking against each other in every direction, soon became a very efficient, though not very handsome, sort of duck shot.

Pistol bullets and rifle balls, requiring to be of exact size, are generally cast in moulds, one at a time; swan shot, and other like sorts, are cast in a similar manner,

Fig. 12.



but several together. The above cut represents a pair of moulds for casting swan shot. They consist of two sides, A B, about ten inches long each, made of brass, and joined by a pin at the end, much in the manner of a pair of common nut-cracks; in the faces of the upper parts, which are made to close very exactly, corresponding hemispherical cavities are formed, having each a little outlet to the edge. When the moulds are closed for casting, the steel plate C is brought over the face until it rests against a pin at D; its row of counter-sunk perforations exactly lying over the holes in the sides. Melted lead is now poured into each hollow through the apertures in the plate; after which, by striking or pressing it on the part at E, the castables, or tails, of the shot are cut off, and the shot taken out of the mould.

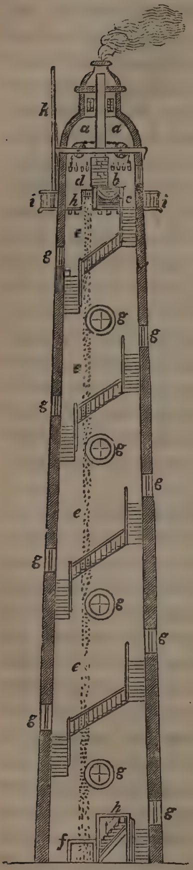
Notwithstanding the generally received opinion, that one principal feature of perfection in a bullet is sphericity, Mr. J. W. Boswell, in an ingenious communication to the Repertory of Arts, recommends the use of balls of the foregoing figures, *fig.* 12. *a, a* as better adapted to move in a straight line through the air, than those of a globular form, and which necessarily assume a rotatory motion in their progress through the barrel of the piece, and consequently take a bias in their projectile direction, determined by their friction against the right hand side, the left hand side, or the bottom of the barrel. The writer of the paper referred to, and whose theoretical observations are too long for quotation, says, "I never, before these experiments, practised shooting at a mark; and yet, with these bullets, from a common pistol, I have often hit a mark six inches square, at fourteen yards' distance, in the proportion of seven times out of twelve shots, when I could not, at the same time, with common balls, from the same pistol, hit it oftener than once in ten times." Any gentleman disposed to try bullets of these forms, might easily cast a few for experiment from well-dried plaster of Paris moulds, if brass ones could not be easily obtained.

The smaller sorts of shot are manufactured in a very perfect manner by granulation, or pouring the metal from a considerable height, in consequence of which it separates into globular masses of different sizes, which cool into that form during their descent, and which cooling is completed by their falling into water. One of the earliest successful practisers of this method was an individual at Bristol, of the name of Watts, a plumber, who, in 1782, obtained a patent for "arsenated shot;" the material of which consisted of soft pig lead saturated with white or yellow arsenic, in the proportion of about forty pounds of the latter to twenty hundred weight of the former. To effect the mixture, the lead, along with the arsenic, was put into an iron pot closely covered, and then heated to redness; this poisoned lead was not used alone, but mixed in various proportions

with that intended for the making of shot. The patent right having long since expired, most of the shot now seen is made of lead having in it some portion of arsenic, by which its sphericity and solidity are improved. To obviate objections which some have made against the arsenated material, a small quantity of quicksilver has been mixed with the lead, and which answers the purpose sufficiently. The following account has been given of the invention of the patent shot by Watts. In consequence of a dream, the idea was conceived of pouring melted lead through a considerable space; and the experiment was tried from the tower of the church of St. Mary Redcliffe, the church immortalised by Chatterton the poet. Watts is said to have sold his patent to the eminent house of Walkers, Maltby, Parker, and Co. for 10,000*l.* With this sum, he proposed to build a crescent at Clifton: the situation chosen was a huge rock, and the whole sum was expended in making excavations, and in raising immense walls for foundations, which long bore the name of Watts's Folly, and upon which walls Trafalgar Place was afterwards erected.

The specification of the patent obtained by the firm above named is inserted in the third volume of the Repertory of Arts, from which work it is here transcribed, along with the accompanying vertical section, *fig.* 13. of the kind of building commonly used in the manufacture of shot. Most visiters to London have noticed the shot towers on the banks of the Thames: these are on the south side of the river; their height is about 150 feet, affording a fall of about 130 feet for the shot. The alloy is described, in the specification, as consisting of forty pounds of arsenic to a ton of lead, prepared as above stated, and cast into pigs to be ready for use. By means of a suitable tackle and chain,—a part only of which, to prevent confusion in the drawing, is brought into view at *a a*,—ten pigs, of about 1½ cwt. each, are drawn up through a trap-door into the melting-room at the top of the tower; here the pigs are successively

Fig. 13.



put into the cauldron *b*, which is heated by a common furnace, *c*, beneath, having a brick flue and chimney, terminated by an iron funnel reaching to the top of the upper dome, or lantern. When the alloy is melted, and the scoria properly formed, a portion of the latter is ladled by the melter into a kind of square colander, *d*, supported in an iron frame fixed close to the furnace; this vessel is twelve or fourteen inches square; it has a handle like a frying pan, and its bottom is perforated with circular holes, of a size suited to the shot about to be made. The quantity of dross required being determined by the experiment of making a few shot (which are not suffered to descend below the floor of the melting-room), a man now ladles the fluid metal out of the cauldron into the perforated vessel; in running through which it is somewhat detained and cooled in passing the scoria, which tends to separate it in small portions, where it collects underneath the colander at every hole in small globules, which instantly drop, and are followed by other globules, in such rapid succession as to appear at a little distance like a pouring rain of liquid silver. This metallic shower is represented in the cut *e e e*, and falls into a large tub of water, *f*, placed underneath. From the great specific gravity of the shot, they do not scatter in their descent;

and the workmen cross the bottom floor of the tower, as their business requires, in perfect security.

This tower is quadrangular, and has four or five windows on each side, represented at *g g*; *h h* represent doorways, the upper one leading into an external gallery, *i i*, which, as may be supposed, commands an extensive and highly interesting view of London and its suburbs; *k* is the stem of a long flag-staff. The staircase, from the bottom to the top of the tower, is of iron, and of great stability; it is represented, of course, as dissected in the engraving; the foot plates are of cast-iron, slightly fluted, to prevent slipping; and there are square landing-places at each corner of the quadrangle, as well as seats for the convenience of the weary or the lazy ascendants and descendants. There are one or two other towers similar in their arrangements, but circular, at no great distance from the one here described. There is a round and lofty shot tower near Newcastle-upon-Tyne, from the balcony of which the spectator commands an interesting range of prospect, including the river with its vast assemblage of colliers and other craft.

The various sizes of the shot are distinguished, by the manufacturers, by the Nos. 1. to 12.: the largest, No. 1., are called swan shot, the smallest, No. 12., dust shot; their diameter varying from one thirtieth to one fourth of an inch. The shot, when removed out of the tub, are dried by artificial heat, as they remain considerably wet, by the water being held between the little spheres by capillary attraction; to dry them, they are scattered over a large heated iron-plate, having a furnace beneath, on which they are well stirred about, and swept off as soon as dry. After this operation, they present a dead white silvery appearance: they contain amongst them many (though but a small proportion) of imperfect shot, and the perfect differ somewhat in size: to separate these varieties from one another constitutes the next process. The dried shot are therefore taken to the sifters, who have each the management of a series of

three or four sieves placed in a row, in a reciprocating iron frame, which derives its motion from a steam-engine: the movement is effected by a horizontal revolving shaft (near the ceiling of the room), having at the extremity a short crank, from which depends a rod that is made to rise up and down; this vertical rod is attached at its lower extremity to a lever of the common bell-crank kind, which is connected to the frame containing the sieves, and therefore produces in the latter a reciprocating horizontal motion. Each sieve is also provided with a distinct frame embracing its circumference, with a large joint on one side, which connects it to the general frame. A quantity of the shot being thrown into the first sieve, that portion of them which is small enough passes through its meshes; the rest, that are too large, are then discharged into the next sieve, by *turning over* the first on its hinge joint, as a person would open and throw back the lid of a box. The advantage of this arrangement will be evident, when it is considered that the sieves, being constantly in rapid motion, it would be no easy matter to throw the shot from one into the other, were they separate, without spilling; whereas, by their connection, the shot cannot be discharged otherwise than as intended. The attendant on the sifting apparatus has therefore only to supply the first sieve, and to discharge the contents from one to the other successively. The produce of the two first sieves is collected into separate bins; and, as these contain many shot of imperfect *forms*, they are taken thence to another set of operators, who separate the bad from the good, by a process equally simple and effectual. Those which have not passed through the two first sieves of the series are condemned as bad, and are remelted.

A number of shallow quadrangular trays, the figure of which may be defined by the boundary line of a plane, produced by the longitudinal section of the frustrum of a cone in the line of its axis, made of hard wood, and perfectly smooth at the bottom, are sus-

pended from the ceiling by cords attached to the two corners of the widest ends of the trays, their other, or narrowest ends, resting upon the edges of a row of shot-bins. Thus arranged, a boy, who manages two of these trays, throws upon each at the widest end (that nearest to him) a small measure-full of shot; he then takes hold of the trays, and, giving them a gentle vibrating motion laterally, and at the same time raising the ends a little, to give them a slight inclination, the shot roll about, tending from side to side, those that are perfectly spherical making their way quickly off the boards into the bin at the extremity; while those which are imperfect are detained by their comparatively sluggish movements, and, being thus separated from the good, the trays are pushed forward about a foot, and their contents emptied into other bins placed beyond those containing the good shot as before mentioned. This operation is so effectual, that it is difficult to pick an imperfect shot out of those that come to market. Four or five boys thus employed, with two trays to each, suffice for a manufactory of the kind above described, which makes about five tons per day. The smallest shot require the utmost care and gentlest management of the inclined plane; therefore the eldest or steadiest hands are selected to operate upon them. The next and last part of the business, previous to the shot being bagged for the market, is to polish them; for this purpose a cast-iron barrel, holding, perhaps, half a ton weight, is nearly filled with them, and a rotary movement communicated to it by the engine, which causes all the little spheres to rub against each other, and gives them a black lustre, materially differing from their previous argentine complexion. It is remarked that a curious effect is produced upon the interior of the cast-iron barrel by the friction of the shot,—that of wearing it into a regular series of grooves; so that a stranger would suppose the barrel had been cast with an internal fluting.

CHAP. V.

PEWTER AND ZINC.

ANTIQUITY AND USE OF PEWTER VESSELS. — COMPOSITION OF PEWTER. — VARIETIES AND PROPERTIES OF THE METAL. — INCORPORATED PEWTERERS. — MANUFACTURE. — DISAPPEARANCE OF PEWTER WARES. — PEWTER PLATES FOR ENGRAVING. — ZINC, ITS MINERAL HISTORY. — MALLEABILITY OF ZINC. — BIDDERY WARE. — TUTANAG.

In few things pertaining to domestic convenience has modern ingenuity effected greater innovation than by the almost universal substitution of potter's ware for pewter among that class of the community in whose houses metal utensils were very plentiful and common even within the memory of persons still living. At what period vessels of pewter were first used in this country, it were impossible accurately to determine, though they are undoubtedly of very considerable antiquity, even if not coeval with the working of our tin and lead mines. During the reigns of the earlier Tudor monarchs, plates of this metal were plentiful in the sculleries of the better sort of houses; where, however, the wooden trencher was the ordinary platter, the former being far too valuable to be regarded other than as silver ware would be esteemed by the same class of housekeepers in the present day. Indeed, so late as the reign of Henry VIII. no small portion of the vessels of the nobility appear to have been of pewter; and in the celebrated "Household Booke" of the duke of Northumberland of that reign, there is a charge for the *hire* of pewter vessels, though the description of them is not ascertained. Of the same date, we have the inventory of a gentleman's butlery, comprising "two basins and two ewers of pewter; one ale pot and two wine pots of the same; two dozen of pewter trenchers; five chargers;

seventeen platters; two dozen of dishes; sixteen saucers; two porringers; two plates; a washing basin; a salte; and a bottle for water," all of the same metal. Although the Romish church enjoins that, where the people can afford it, vessels for the holy offices of religion shall be made of silver, many of these were formerly of pewter; and in protestant communities, as well in this country as on the continent of Europe, especially in Germany, chalices and salvers of pewter were common before the introduction of plated and Britannia metal wares; the latter being a compound metal analogous to pewter.

Pewter is a compound of tin and copper; the latter being in the proportion of about one part to twenty of the former. Other metallic ingredients are sometimes added, according to the experience of the workman; as lead, zinc, bismuth, and antimony. Dr. Ure says there are three sorts of pewter, distinguished by the names of plate, trifle, and ley-pewter. The first was formerly much used for plates and dishes; of the second are made the pints, quarts, and other measures of beer, so common in London; and of the ley-pewter, wine measures and large vessels in general. The pewterers are anxious to unite in their wares the greatest degree of hardness with a white or silvery colour; and it is this which has led to such a diversified use of the above-mentioned ingredients. Various objections have, at one time or other, been raised against the large intermixture of lead or copper in the composition of culinary utensils; and not without reason, when the articles are intended to be subject to heat. As a precaution against anti-salutiferous properties, the more tin pewter contains, the better it is undoubtedly; on the other hand, it is worse as it contains lead in excess: not, however, that any deleterious effects are to be apprehended in the latter condition of the alloy as usually exhibited. Immense quantities of pewter utensils are in use among the continental nations; and, at one time, the whole population of Madrid were frightened by statements,

made by interested parties, relative to the danger of using any vessels composed of a mixture of lead; and laws have been made, as well in Spain as in other countries, to regulate its admission into different wares; at the same time, the uninitiated public have continued to use both tinned and pewter vessels, without troubling themselves whether they were made according to law or not. The pewterers of this country have been an incorporated society ever since 1474, temp. Edward IV. By act of parliament, 25 Henry VIII., their wardens had the inspection of pewter throughout England.

Pewter wares are mostly formed by hammering or casting; plates and dishes by the former, and measures and spoons by the latter process. In soldering the various parts of certain articles together, with soft solder, the workmen employ a blast of hot air. This clean and convenient agent is procured from a small circular furnace, formed exteriorly of sheet or cast-iron, and lined with fire-bricks. It is supplied with charcoal, and the air from a pair of bellows is thrown in, by an iron pipe, so as to pass through the burning coals, and to escape through another iron pipe on the opposite side above in the heated state. The parts to be soldered, having a little oil previously applied to them, are held in the stream of hot air until a thin slip of solder applied to them melts and flows between, and unites the parts firmly together. The solder is composed of five parts of lead, three parts of tin, and one part of bismuth. The last-named substance is remarkable for the extreme fusibility which it imparts to the alloys into which it enters with some other metals: if eight parts of bismuth, five of lead, and three of tin, be melted together, the composition will melt at a heat no greater than 212°, the temperature of boiling water. Tea spoons made with this alloy are sold in London, to surprise those who are unacquainted with their nature: they have the bright appearance of pewter, but melt as soon as they are put into hot tea. The British manufacture is almost confined to London; the wares are of

excellent quality, made and stamped according to law, and exported to almost every part of the world. Most readers will recollect that the late captain Clapperton mentions that, while residing at the court of the sultan Bello, in Africa, his provisions were regularly sent to him, from the sultan's table, on pewter dishes with the London stamp: and the navigator, captain King, records, with great satisfaction, that, while wintering in the Russian harbour of St. Peter and St. Paul, on the east coast of Kamschatka, the most pleasing ideas of home were excited by the sight of an old pewter spoon, with the word "London" stamped on the back of it. Although the introduction of cheap and beautiful pottery had largely superseded the use of expensive pewter ware long before the commencement of the present century, it was not until the war with France had raised the price of tin so greatly that the pewter dishes disappeared so generally in the country. The pedlar of that period found them a convenient exchange for his articles: he, on entering a dwelling where these wares were displayed, —

—— "Bewail'd the times
Which form'd such ponderous garniture;
And slily hinted at their want of taste
Who kept such massive lumber for no use;
So costly too, — when cheap, neat, delicate,
And milk-white earthen dined the neighbouring squire!
Wedgewood, his history, potteries, praise,
Furnish'd a ready theme: the cunning Jew
Plied every art of speech and fraudful trick
To purchase what he proved of little use:
Till, won by arguments, the simple dame
Consented — sold, and parted with her plates."

Sheet pewter was the first metal used in plate engraving: there were, formerly, in the library of the earl of Pembroke, prints by two Florentine artists, Pollaislolo and Montegno, who both engraved exclusively upon this metal, about 1460. Albert Durer, also, who became noted in the succeeding century for his works

upon wood and copper, first wrought upon pewter. It long continued to be almost exclusively used by the engravers of printed music: it presented the twofold recommendation of cheapness in getting up, and convenience of working upon by the artist, who, instead of cutting out the characters with a burine, or even tracing them with the etching needle, simply ploughed the parallel lines right across by ruling, and then, by means of punches, indented the notes in the metal. A knowledge of this method will account for the slovenly execution of some cheap printed music. Latterly, the great demand for musical works, and also the method of printing the characters from types, have led to great improvements.

Zinc is a metal which, when manufactured, a good deal resembles pewter in external appearance; it is less known, however, to the arts in this state than on account of the value of its ores in the composition of brass. In the metallic form of spelter, the Greeks and Romans are supposed to have been unacquainted with it; though one of its ores, under the appellation of cadmia, was probably known to the former people. In China this metal abounds; and, formerly, immense quantities of spelter were imported into Great Britain, by the East India Company, for the use of our manufactures: the British metallurgist meanwhile remaining ignorant of the existence, in great abundance, of the ores which were capable of yielding it in our own island. The ores of zinc occur in scarcely inferior abundance to those of iron, and under a variety of appearances, — particularly those known among chemists as oxides, carbonates, and sulphurets: it is generally in combination with the lead ores, and, consequently, it is for the most part found in those situations where the working of plumbiferous strata is carried on. In this country, the mining districts of Derbyshire, Durham, Cumberland, Nottinghamshire, Yorkshire, Somersetshire, and some other counties, yield the ores of zinc; as do likewise North Wales, and several countries on the continent of Europe. A description of the ore of a blood-red colour,

and well adapted for brass-making, has been found in some of the iron mines of North America.

Immense quantities of the ores of zinc, both in the state of calamine, an oxide, and of blend, which is a sulphuret, are found in Derbyshire: the latter is called by the miners, from its appearance, *black Jack*. This substance, which sometimes exhibits congeries of black crystals of considerable beauty, was, nevertheless, from an ignorance of its metalliferous properties, long used in Wales for mending the roads; while in Derbyshire its value was equally unknown. Monsieur von Swab was, according to bishop Watson, on the authority of Cronstedt, the first person who, about 1738, obtained zinc from *black Jack;* and from him the hint of our English manufacture of this metal is supposed to have been taken or purchased. The extraction of the metal is effected by distillation, *per descensum*, in an iron crucible; or, when used in the making of brass, it is roasted, pounded, picked, and, in that state, mixed with the granulated copper. For the latter purpose, however, the calamine, or lapis calaminaris, as it has commonly been called, is considered the most valuable.

Zinc, when cast into a mould, although not absolutely without malleability, readily breaks to pieces under the hammer when cold, exhibiting a peculiarly brilliant fracture: quadrangular prisms, apparently composed of small plates, and disposed in little bundles, are formed during the crystallisation of the metal while cooling. It is vulgarly supposed to be an efflorescence of this beautiful structure which is exhibited by suspending a piece of zinc in a bottle containing pure water saturated with sugar (acetate) of lead: the real cause, however, is, that the lead is precipitated upon the zinc, so as to form that brilliant metallic leafage, which has been called, not inappropriately, *arbor plumbi.*

Although zinc, when first cast, thus breaks under the hammer at the temperature of the atmosphere, on being heated to about 212° of Fahrenheit's thermometer, it admits of being reduced into sheets, and even into a very tenacious wire, with considerable

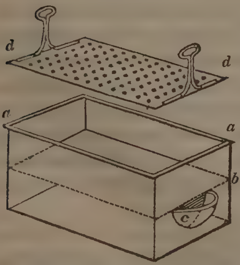
facility: at 680°, according to Dr. Black, it melts; and, at the medium temperature, it is sufficiently brittle to be reduced to a powder in the mortar. Zinc, in the form of plates, is the metal generally used with silver or copper, in the formation of galvanic apparatus, for which purpose it is peculiarly suited.

In 1805, Messrs. Hobson and Sylvester obtained a patent for a method of manufacturing zinc into wire, and into vessels and utensils for culinary and other purposes. By their process, zinc (which had heretofore been called a semi-metal, because not malleable, and scarcely capable of extension, by mechanical means, at the ordinary temperature of the atmosphere, or at those heats which are applied in the forging and extending of metals in general) was capable of being extended by hammering, laminating, wire-drawing, pressing, stamping, &c., as in the working of other metals. The zinc was cast into ingots, or thick plates, in the usual manner, or into cylinders for the purpose of making wire. These pieces, when intended to be mechanically wrought, were heated in an oven, or by any similar contrivance, to a temperature between the degrees of 210° and 300°, or thereabouts, according to the scale of Fahrenheit's thermometer. For making wire, it was recommended, as most convenient, that the cast cylinders should be extended between grooved rollers, at the above temperature, till their lengths were increased to about four times; after which they might be drawn through the wire-plates without farther annealing. Plates of zinc, rolled at the above temperature, might be hammered into all the variety of vessels usually made by the brasier or tinman, care being taken to heat the work occasionally during the operation. When it was necessary to unite pieces or plates of zinc, a solder was used, consisting of two parts tin and one part zinc: or even the common glazier's solder may be used.

In the same year, Mr. Sylvester specified another patent for applying sheets of zinc or spelter for sheathing ships, roofing houses, and lining water-spouts. In men-

tioning the applicability of this metal to the first of the foregoing purposes, the patentee adverts to those principles of voltaic action which were so eminently illustrated, some years afterwards, by sir Humphrey Davy, in his " Inquiries into the best Methods for protecting the Copper on Ships' Bottoms." Mr. Sylvester says, — " The best general rule or instruction for applying metals or fastenings for zinc or spelter sheathing on ships, is to take that metal which is nearest in that power which chemists call galvanism to zinc or spelter itself, and causes the least quantity of oxydation when made with the latter metal into a galvanic pile." Pope and Co., of the battery works near Bristol, have also a patent for malleable zinc for covering buildings, &c. Dr. Watson, several years ago, described the zinc made here, as being " whiter and brighter than any other, either English or foreign." According to the testimony of Dr. Brewster, zinc, rolled into large plates, is now a good deal employed as a substitute for lead and slates in the covering of buildings both in Britain and on the Continent. The great advantage of these plates is their lightness, being only about one sixth part the weight of lead: besides they are not liable to rust, which is another advantage. It has long been known that vessels of zinc were favourable to the obtaining of a superior quantity of cream from new milk placed in them, and patents for applying the metal to the manufacture of dairy utensils have been taken out in America, if not also in this country. In the Transactions of the Society of Arts for 1832, there is an interesting account of some experiments on this subject, together with a description of a vessel for separating cream from milk, and an attempt to account

Fig. 14.



for the effect produced in this process by the action of the metal upon the fluid, by a Mr. Carter, of Nottingham Lodge, near Eltham. The preceding cut (*fig.* 14.) represents a four-sided vessel, *a a*, formed of zinc plates, twelve inches long, eight inches wide, and six inches deep, with a false bottom, *b b*, at one half the depth. The only communication with the lower compartment is by the lip *c*, through which it may be filled or emptied: *d d* is a plate of perforated zinc, with a ring-handle at each end; its area is equal to that of the false bottom upon which it is placed, and the milk, fresh from the cow, is immediately poured upon it in the upper part of the vessel: after standing twelve hours, the under part is to be filled with boiling water by the lid *c*; when, after remaining twelve hours longer, the cream, which is often so stiff that it might be lifted off by the fingers in one piece, is conveniently removed by gently raising the plate of perforated zinc from the bottom by the ringed handles. Mr. Carter, who reckons the increase in the quantity of the cream, from the use of these vessels, at 12 per cent., and of butter, at upwards of 11 per cent. as compared with the old method of gathering, hazards a conjecture that these results are "owing to a galvanic effect, which is produced by the lactic and acetic acids (developed in the milk by heat and rest), acting slightly on the zinc plates of the vessel. We have, therefore, two fluids acting on one metal; which is well known to be a galvanic arrangement of the second order. The acids, which would otherwise cause the coagulation of the milk, are thus token up by the zinc; and the milk, by remaining more perfectly fluid, admits the easy ascent of the suspended cream. I have ascertained, on analysis, the presence of acetate and lactate of zinc in the skimmed milk; which would, therefore, seem to favour the hypothesis."*

* The impregnation of the milk with with soluble salts of zinc, and the well-known astringency and acid quality of these salts when in a state of moderate concentration, induced the committee to enquire what use is

Somewhat analogous in composition to the factitious metals last mentioned, is the celebrated Biddery-ware of the East Indies, so often noticed by travellers, and deriving its appellation from Biddery, a large city about sixty miles north-west from Hyderabad. Of this metal, hookah bottoms, dishes in which betel is handed, and other articles, which the means of the owners do not allow them to obtain of silver, are manufactured by Hindoo workmen with great address, not only at the above-named city, but also at Benares. Biddery-ware, when its metallic colour is brought out, a good deal resembles some sorts of pewter or zinc; but the natives of the East prefer to give it a sable hue: they also inlay it with silver at the expense of much labour and ingenuity. Dr. Heyne, who visited Biddery about twenty years ago, for the purpose of obtaining information relative to this ware, informs us that it is composed of copper, 16 oz.; lead, 4 oz.; tin, 2 oz. These are melted together, and to every three ounces of the alloy sixteen ounces of spelter is added, when the metal is melted for use. To give to the ware its esteemed black colour, it is dipped into a solution of sal ammoniac, saltpetre, common salt, and blue vitriol.

The tutenague, formerly so important an article of commerce between the East Indies and this country, is a white metallic substance, of which the Chinese make vessels and candelabra. "Its exact nature," says Malte Brun, "is still a problem." Some say that *tuetenague* is the name given by the Chinese to zinc; others consider that it is an artificial mixture of different metals, while the tutenague of India, according to them, is pure zinc, without any alloy of lead. M. de Guignes affirms that it is a native mixture of lead and iron peculiar to China: according to this authority, the province of Hoo-quang contains a mine which furnishes

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made of the milk after separation of the cream. Mr. Carter replied, that it is employed wholly in feeding pigs; and the animals do not appear to be at all injuriously affected thereby.

it in great abundance. This metal has frequently been confounded with the white copper of China, which is of a different composition, and not allowed to be carried out of the empire. In No. XV. of the Edinburgh Journal, are some observations on the subject by sir T. Dick Lauder, Bart., in which he states, on the authority of a friend, employed for many years in the trade between India and China, that "the white copper is used by the Chinese themselves; who are so jealous of permitting other nations to have it, that its exportation is contraband. In defiance of this, however, considerable quantities of it are smuggled out of the country, and introduced into India, where it is considered a great present to the Hindoos, &c., who make domestic vessels of it. The tutanag, on the contrary, is an article of very extensive commerce between China and India; and my friend informs me, that it is sent from China in slabs, of which he has had occasion to buy and sell many thousands. The slabs are about eight or nine inches long, by about five and a half wide, and about five eighths thick. Its colour is greyish; and it is not malleable, but so brittle that is even necessary to use considerable caution in putting it on ship-board, to prevent its being broken by one piece striking against another. The fracture has a glittering lustre, and somewhat resembles the appearance exhibited by that of bad iron; but the crystallization (if that term may be employed) is larger. It does not ring, but emits a heavy clattering sound. It is employed by the natives of India as an alloy for copper to make brass for their domestic utensils."

Such was the description of this celebrated metal about 1820, until which period the interests of the importers had invested it with as much mystery as possible: in that year, however, the British free traders introduced German spelter into India, to compete with the Chinese metal, the similar composition of which they had discovered. In 1826, the importation of tutanag from China into Calcutta ceased; and it is now

totally superseded throughout India by spelter. Of this latter commodity there were, according to M'Culloch, exported from British ports, at an average of the three years ending with 1828, 126,320 cwt. of the declared value of 95,000*l.*, besides the quantities furnished by Hamburg, Rotterdam, Antwerp, and other continental ports.

CHAP. VI.

BRITANNIA METAL.

BRITANNIA METAL HAS LARGELY SUPERSEDED THE USE OF PEWTER. — BEAUTY AND CHEAPNESS OF THE WARES. — COMPOSITION OF BRITANNIA METAL. — ROLLING. — VARIETY OF ARTICLES FABRICATED. — FACILITY OF STAMPING. — SPINNING TEAPOTS. — FLUTING AND EMBOSSING. — SOLDERING. — CASTING AND TURNING. — CASTING SPOONS. — BUFFING AND BRUSHING. — HAND POLISHING. — EXTENSIVE MANUFACTORIES.

The general disuse of the old pewter ware, once so common in this country, has been followed by the introduction of another metal, in the manufacture of which a degree of ingenuity is constantly displayed, to which the ancient pewterers were altogether strangers. The modern material, the base of which is tin, has been called Prince's metal, more commonly Britannia metal, and by the workmen white metal. It is not only wrought into all the variety of elegant and useful articles to which silver is applied, but, along with its capability of receiving almost every modification of which that precious metal is susceptible, it also very much resembles it in colour and brilliancy. It possesses also, when quite new, and in some articles of a fine quality, candlesticks in particular, an effect which an inexperienced eye might easily, before the metal became common, have mistaken for silver. The beauty of this metal, when wrought into a variety of articles, is not more striking than its cheapness in the manufactured state is surprising. This latter circumstance results, independently of the price of the material itself, from the extensive application of machinery, and the extreme lightness of body with which wares in Britannia metal can be produced; a lightness, however, which is always ob-

tained at the expense of durability, as well as of shape. A quart tea-pot, for example, of a most elegant pattern, mounted on four balls, and flourished with engraving, may be bought in the shops for so trifling a sum as three or four shillings; and hence, nothing is so common in an ordinary tea-table display, among even the middle classes, as an utensil of this description: and almost as common is it, in those cases where cheapness has supervened, to find the article sadly bulged and warped from its original symmetry; an effect which the hot water therein used, along with the constant lifting and placing the pot upon the table, unitedly produce in a very short time, when it is of such a flimsy make.

The principal, if not, indeed, the only seat of the manufacture of this metal, is in Sheffield, where its composition and application on a large scale was begun about the year 1770, by two individuals of the names of Jessop and Hancock. Its conversion into a great variety of beautiful wares probably gives employment to about 500 individuals in that place.

The composition of Britannia metal is as follows: — $3\frac{1}{2}$ cwt. of best block-tin; 28lbs. martial regulus of antimony; 8lbs. of copper, and 8lbs. of brass. The amalgamation of these metals is effected by melting the tin, and raising it just to a red heat in a stout cast-iron pot or trough, and then pouring into it, first the regulus, and afterwards the copper and brass, from the crucibles in which they have been respectively melted, the caster meanwhile stirring the mass about during this operation, in order that the mixture may be complete. The fusion of the whole being completed, by the continued application of the fire for a short time under the pot, the liquid metal is, in the next place, transferred therefrom by means of large iron ladles, to the casting-boxes, which are composed of cast iron, and give to the metal poured into them the form of a slab 15 inches long, by 6 inches wide, and 1 inch thick. It is likewise put into other moulds, forming small ingots, for the convenience

of being used in the casting of such articles as are not made out of the sheet metal.

The rolling or flatting of the metal into sheets, is performed exactly in the manner practised in the lamination of metals generally, that is, by passing it repeatedly between polished steel cylinders. The metal, although possessing some degree of hardness, is not susceptible of being softened or annealed by any process during the operation of rolling: and it becomes somewhat shattered or cracked along the edges. To prevent as much as possible this evil, the ingot is not rolled cross-way, so as to form a broad or square sheet, but simply elongated, retaining as nearly as possible the original breadth. Considerable attention is exercised in keeping it to the exact thickness required; and for this purpose, the gauge is repeatedly applied; for, so nicely are the trade prices balanced against the value of the metal and the cost of manufacturing, that a very slight deviation from the proper size, may make all the difference between profit and loss upon the sale of the articles.

Although, as already stated, almost every article manufactured in silver has now its counterpart in Britannia metal, the greater part of the material used is in the production of candlesticks, teapots, coffee-biggins, and all kinds of measures for liquids. The feet of candlesticks, and the bodies of tea-pots or other vessels, when presenting embossed work, and of any other than a circular form, are made by means of dies in which they are stamped. When the shape of the article is cylindrical, and ornamented with raised work, it is sometimes stamped in halves which are afterwards fitted and soldered together, or, when globular, it may be stamped in three or more pieces, according to the depth of the work or size of the article. The machinery of the stamp, and the mode of working it, resembles those employed in the manufacture of brass and silver, hereafter to be described: there is, however, one important difference in favour of the working of the metal now under

notice. In the stamping of brass work, unless the articles happen to be very large and coarse, and in performing the same operation with silver, and plated metal especially, the dies are not only required in almost every instance to be made of steel, but the figure of the article designed by the artisan has to be cut in them at great labour and expense; so much so, indeed, that the die-sinking, and the metal upon which it is expended, constitute one of the heaviest items of expense in manufactories where the above-named metals are wrought. And this expenditure is greatly enhanced, not by the wearing of the dies when finished, but by the continual demand for new patterns. The Britannia metal worker has a readier method. He either forms a model of his article, when the design is new, or, what is more frequently the case, having obtained some fashionable silver plated article, he takes it to pieces, and from the stamped parts he casts fac-similes in plaster of Paris, and from the matrices thus produced, a counterpart, in relief, is moulded by a similar process and of the same material as in the first instance. Upon this model is ultimately cast the die, of fine hard pig-iron; and which, after having been got up with emery, and perhaps slightly retouched, to give sharpness in some of the lines, with a steel tool, is ready for use. In the making of dies for round or oval-shaped articles, the adoption of this method is of less consequence, as the turning of them at the engine is easy and inexpensive. Indeed, so tractable is this metal, particularly when very thin, that in this state it is often stamped in dies made of brass, and even of spoon metal.

The bodies of those tea-pots which are of a globular form, or which exhibit concentric and circular swells, are mostly made by a curious operation, technically called *spinning*. In the performing of this work, steam power is generally used at the larger establishments; but it is rather by great manual dexterity than by means of intricate machinery, that the workman produces such amazing and rapid transformations of the

tractable substance upon which he operates. Upon a spindle, rapidly revolving in a horizontal position, is fixed a wooden chuck, or model of the pot or other article to be formed; or rather of so much of it as will allow the metal to slip off the wood after it has been closed upon it. A piece of sheet metal is cut with shears into a circular shape, and of the size required: this is placed against the end of the revolving chuck, and against the metal outside is applied a circular bit of wood, having an indentation in the middle, where a centre pin of obtuse form is screwed firmly upon it: thus placed, and while it rapidly spins round, the workman applies various tools, either of hard wood or of polished steel, in the first place very gently, until, by a succession of touches, he bends the plate over the model-chuck without either crumpling or laceration. The article is afterwards placed in a similar manner against another chuck, and the spherical or other form perfected. Some of these articles are partly formed by a stroke in a die previous to the spinning: in others, in which the metal is made to overlap the model, the latter is composed of segments, so as to be removable on the withdrawal of the middle piece, somewhat in the manner of a boot-last. In general, however, vessels intended to be perfectly spherical, are executed only in halves, or even smaller portions at a time. This manipulation, like that of forming a vessel of clay on the potter's wheel, would be quite beside the reach of an unpractised hand, yet there are individuals, who have been long accustomed to the work, who can spin twenty dozens of these pot bodies in a day!

The fluted work put in obliquely, or at right angles to the circular design of many utensils, and which add at once so greatly to their strength and beauty, is performed by means of a large fly-press; one workman applying the metal between the punch and boss, properly formed for making the impression, while another keeps swinging backward and forward the weighted lever arm of the machine. Embossed ornaments, of a

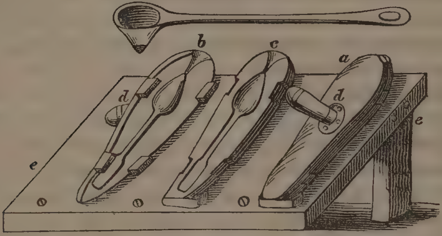
character of elegance little, if at all inferior to those displayed on silver plate, are commonly applied to the superior products of this branch: the practice has of late years been introduced of making these ornaments of silver stamped in sheet metal exceedingly light.

In the manufacture of Britannia metal articles, a soft solder is used, consisting of fine tin, alloyed with about 30 per cent. of lead; this is rolled into sheets, about the thinness of common tin, and then cut into slips for the convenience of holding and application. In using this solder, the seams of the metal, where the joining is to take place, are scraped clean, and then smeared with a composition of melted rosin and oil: the flame of a candle is then made to play upon the part, by means of a small blowpipe, held in the mouth of the workman, while he holds the article under the operation in one hand, and applies the slip of solder with the other. Extreme caution is required in the management of this affair, especially when the metal is thin, in order to avoid melting the body as well as the solder. In general, however, the operation is performed with singular ease and rapidity by an experienced workman; and there are few sights more pleasing to a stranger than the method of soldering this and other metals. The extreme fusibility of Britannia metal wares has led to some whimsical mishaps in the attempts of travelling tinkers to mend them when injured: the soldering iron has been applied; and instantly, instead of stopping a small hole, the inexperienced botcher has made one large enough to receive his thumb.

Imperial and other measures are made of Britannia metal, in great numbers: they are either formed by doubling and soldering the material as cut from the sheet, or cast at once in brass moulds, and afterwards turned inside and out at the lathe; and, lastly, the handles, which are cast separately, are soldered on. Numerous other things are cast with great facility, and afterwards finished by turning. One of the most valuable uses to which this metal is put, is the manufacture of spoons of

different sizes: of these, the quantity made and sold at home, as well as exported every year, is inconceivable. As a substitute for silver, and for daily use in ten thousand instances where silver is never found, these spoons are a cheap, cleanly, and durable ware. They are cast singly in brass moulds, which have been formed with great nicety for the purpose, and which are used with great facility. The annexed sketch (*fig.* 15.) re-

Fig. 15.



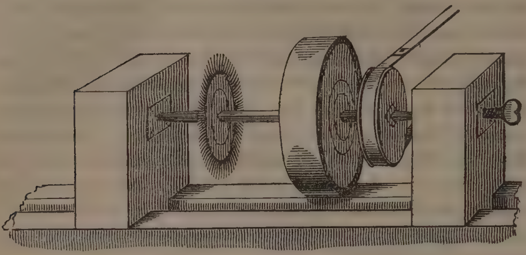
presents two pairs of spoon moulds, which is generally the number managed by a single caster, the metal being left to cool a little in the one last filled while the spoon is removed, by means of a pair of pliers, from the other: *a* shows the mould as closed up and ready for the reception of the metal by way of an orifice at the upper end: *b c* are the two parts of another mould separated: *d d* are handles, by which the upper part of the mould is removed: *e e,* is an inclined board fixed upon the work bench, near to which the caster sits, and within reach of the metal-pot: *f* is the ladle, partly covered with a lid of sheet iron, which prevents the scum or dross from passing in the mould. The metal used for this purpose is made much harder than that which is rolled into sheets: the spoons are accordingly stiff, and admit of a high polish; but they are at the same time proportionately liable to break, if bent considerably, though by no means so brittle as to fail with ordinary usage. To render their fracture, however

next to impossible, the ingenious device has lately been hit upon, of casting them with a narrow slip of tinned iron along the inside of the shank; and by means of which they are surprisingly strengthened, while the price is hardly at all enhanced. After they come from the mould they are scraped a little, stamped with the maker's name, and then polished as we see them in the shops for sale. Measures, and a number of other articles of similar strength and formation, are moulded and cast in sand, and afterwards engine turned. It should be observed, that Britannia metal is not only one of the most tractable of substances to work from the sheet, as well as one that runs most readily in the moulds; but it is also one that is cut most freely and pleasantly by the tools of the turner.

In getting up articles of this metal, the oil and rosin, and other dirt are removed by boiling in water containing sweet soap; after which the buff, the brush, and, lastly, hand-polishing are resorted to. The buff is a solid trundle of wood eighteen inches, more or less, in diameter, and two or three inches in thickness: it is covered on the rim or periphery with a coating of buff, or thick soft leather, from whence the name is derived. This leather is dressed with sand, mostly brought from the bed of the river Trent, and having been dried, and passed through a sieve, is afterwards mixed with oil, in consequence of which it not only adheres to the buff, but produces a better polish on the surface of the article, which is applied when the buff is rapidly revolving, by means of the machinery to which it is attached. In the case of those articles to which from their form the buff cannot be applied, as well as in those parts which exhibit stamped or embossed work in general, the brush is used. This brush has a round body of turned wood, about which the bristles are inserted in four or five rows, and forming a compact circle about the size of a man's hat-crown. This circular brush is fastened upon a spindle, which by means of a pulley is made to revolve rapidly

in the same manner as the buff: they may, indeed, be run on the same spindle as here represented (*fig.* 16.)

Fig. 16.



Fine Trent sand, and afterwards pounded rotten-stone and oil, are used in dressing the brush as well as the buff; and it will easily be imagined that, from the rapid revolution of both, the stuff which is laid upon them flies off against the workman. This is so much the case, and the sand and oil become so mixed with metallic matter, that it is not easy to conceive the black and filthy appearance of the persons and dresses of the individuals employed in this department. When the articles have undergone these operations, they are boiled in a solution of pearl-ash, and finally hand-brushed and hand-polished, by an application of soft soap, a little oil, and pulverised rotten-stone. It is a singular fact that, not only does there appear to be no substitute for the application of these substances by the hand in finishing, but that it is only a *soft hand* which can successfully apply them. Hence the hand-polishing of Britannia metal wares is performed by females, considerable numbers of whom are so employed in the large manufactories at Sheffield: and the first thing done by a master, when a woman applies for work in this department, is to examine the softness and suitability of her hand.

There are several considerable establishments for the

manufacture of Britannia metal wares in Sheffield, and also in Birmingham. Mr. Vickers, of the former place, the son of an individual who has been considered to be the founder of the trade, is well known for the excellency of his goods: as are also the Messrs. Dixon and Sons, whose concern, called "Cornish Sloce," is certainly the most complete and extensive in the world. In addition to the agency of a powerful steam-engine, this firm employs from 300 to 400 workpeople on the premises, where every operation, from the smelting of the regulus used in the composition of the metal, to the cutting up of timber into the handles and knobs of tea-pots, may be witnessed in a few minutes!

CHAP. VII.

TYPE FOUNDERY.

ARTS OF TRANSFERRING DEVICES BY IMPRESSION OF HIGH ANTIQUITY. — EGYPTIAN HIEROGLYPHICS STAMPED. — CHINESE BLOCK PRINTING. — ENGRAVED AND FUSILE TYPES INVENTED IN EUROPE. — FAUST AND SCHOEFFER. — DESCRIPTION OF EARLY TYPES. — INTRODUCTION OF VARIOUS SORTS. — WILLIAM CAXTON AND WYNKIN DE WOORDE. — WILLIAM CASLON. — BASKERVILLE. — JOHN GOTTLOB. — TYPE FOUNDING. — MOULDS FOR CASTING. — THE MATRIX. — TYPE METAL. — PROCESS OF CASTING. — DRESSING THE LETTERS. — ITALIC AND SCRIPT. — LARGE LETTERS. — INVENTION OF STEREOTYPE. — ADVANTAGES OF STEREOTYPING. — METHOD OF MOULDING AND CASTING THE PLATES. — PREPARING THEM FOR PRINTING.

The art of impressing one substance with another, figured in such a manner as to transfer a fac-simile of the sculptured part, is undoubtedly of very high antiquity. The engraved gems of the Egyptians, Greeks, and Romans, and the signets of the Hebrews, were contrivances for this purpose, to say nothing of the various descriptions of mould stamps for ornamenting different articles, with which they appear to have been well acquainted. What analogy these might bear to the metal printing punches now in use, we are not particularly informed; though the ancient Egyptians are supposed to have been acquainted with these or similar tools; for, in an elaborate description of the opening of a mummy case, before the Leeds Philosophical Society in 1828, the writer, after mentioning that the face and head were overlaid by a piece of red leather divided into three straps, adds, — "the figures and hieroglyphics upon this ornament are evidently the impressions of heated metal types." The knowledge, however, of the art of engraving and of producing copies by means of impressions, whatever may have been the extent or perfection to which it was carried by the people above

named, appears never to have led them to think of applying any of their contrivances in aid of literature. To the Chinese belong the invention of multiplying books by this method, or by the process called block-printing; and which is said to have been found out and practised in the celestial empire, at least before the year 1000 of the Christian era.

A variety of opinions have been entertained by different writers on the subject, as to the time when, and by whom, the art of printing was introduced into Europe; and more especially as regards the invention of separate fusile types; an invention justly considered of so much importance, that its merit has been claimed for almost as many cities as contested the honour of having been the birthplace of Homer. It appears that the earliest attempts at European printing—but whether first in Germany or in Holland is disputed—were made with wooden blocks, about the year 1440. To these soon succeeded letters separately cut on wood, which were transposable into new combinations after each page had been printed off, in the same manner as our modern types. Books printed with these characters are still extant, and are distinguishable by the difference in the size and shape of similar letters. To engrave the letters on bits of brass or other *metal* was an obvious improvement actually adopted; it was soon, however, superseded by the discovery of a method of casting the types of lead, which was brought to comparative perfection about the year 1450, by John Faust, of Mentz, a considerable city on the Rhine.

It would be out of place here to enter at all upon those disputes which have taken place among the learned relative to the diversified claims of the earliest printers, as principals or participants in this valuable discovery. Peter Schoeffer, who became the son-in-law of Faust, is said to have effected considerable improvements in the making of punches and matrices; and particularly in discovering a new mixture, much better adapted for the casting of types than the soft metal they had previously

used. The first types were cut so as to resemble as much as possible the characters used by the scriveners of that time; and upon this circumstance has, probably, been founded the story of Faust's selling the first printed Bibles for written ones in Paris, and of his being charged with magic, in producing them so rapidly, so cheaply, and so exactly alike. The similarity to the manuscript works of the time was much favoured by the circumstance, that all the capital letters were left to be delineated with the pen, and beautified by the process of illumination practised by the ingenious artists upon most books then known.

The collections of types possessed by the first printers were far from including even the necessary varieties for ordinary purposes, so that abbreviations in spelling, and blanks left to be filled up with the pen, were very common in the earliest printed books; Greek characters, particularly, were of much later introduction than the original fusile types, which were a rude Gothic mixed with the letter called Secretary. The first points used were only the colon and the full stop, as still retained in some old versions of the Psalms; the appearance of the hyphen, where words are broken at the end of lines, and even the spacing out of the lines themselves to an equal length, are indications of improvement in the art. An intermixture of rubrics or red letters was very common at an early period.

Printing was carried to Rome in 1466, in the time of pope Paul II., and that pontiff liberally encouraged the printers, who prepared under his auspices the first elegant round Roman character: they also invented such a variety of spaces as kept a beautiful distance between the words; an arrangement to which but little attention had before been paid. Venice became noted at an early period for the beauty of the Gothic types used by the printers settled in that city; hence their books, and even some that were surreptitious, were recommended to the reader as printed *characteribus Venetianis*, with Venetian types. The character now called *Italic* was invented by Aldus, a famous Venetian printer, and

called from him *Aldine*, or *Cursivus* and *Cancellarius:* it was used in printing quotations, until set aside in this respect by the double commas, or Guillemets, as they were at first called, after their inventor, a French printer of that name. Before the year 1470 the art was introduced into France; and the Parisian printers obtained an early reputation for the beauty of their types, as well as for the fineness and correctness of their impressions. Some of their earlier works were in a style resembling the writing of the time; but such as was done (*stannea manu*, as Aldus expresses it) with a heavy hand. The French set the example of adorning printed books with curious cuts, head and tail pieces, initial letters, rubrics, and other embellishments of that nature; the great number of Bibles and church books printed by them, affording a wide scope for the exercise of their ingenuity in this particular. It will easily be conceived that, in the infancy of the art, the cutting of steel punches to be used in sinking the matrices for casting the letters, would depend, for the excellency of its performance, upon the skill of the engraver; the goldsmiths were often the most expert in this line, and hence some of the most beautiful of the early founts of letters are believed to have been executed by them. The Cenninis, father and sons, who first set up printing in Florence, were goldsmiths, and cut the punches which were the originals of the types used by them. The first Hebrew characters were cast and used by the Jews, at Soncino, near Milan, soon after the year 1484.

In 1529, a very curious and elaborate work was published in Paris, by the author, Godfrey Tory, a famous printer and bookseller of Bourges, entitled "CHAM-FLEURY, *auquel est contenu le Art et Science de la deue et vraye proportion des Lettres Antiques, qu'on dit autrement Lettres antiques, et vulgairement, Lettres Romaines, proportionèes selon le corps et visage humain.*" In this singular production the author endeavours, according to the title-page, to demonstrate the due proportion of letters from those of a human body and face.

The art of printing is generally allowed to have been brought into England about the year 1470, by William Caxton, who set up his presses and carried on his operations in the old almonry of Westminster Abbey, where he printed a great number of books, considering the infancy of the typographic art. The types with which this eminent man printed were peculiar, being that mixture of the Secretary and Gothic shape already mentioned; the size, that known among printers as great primer. He had under him several excellent workmen, particularly Wynkin de Woorde, a Dutchman, and Richard Pynson, a citizen of London; both of whom afterwards became printers of reputation. Whether or not Caxton cast his own types, may be doubted; as he certainly imported the art from abroad, so he might also the materials, which he never altered or improved; on the other hand, the founding of types was at that early period a chief feature of the skill and credit of the practisers of the recent invention. Of Wynkin de Woorde, who greatly improved the art, we are told that, on setting up for himself, his first care was to cut a new set of punches, which he sank into matrices, and cast therefrom several sorts of printing letter, which he afterwards used. Palmer mentions a singular circumstance, which induced him to think this celebrated printer was also his own letter-founder; namely, that in some of his first printed books, the letter he made use of (great primer and two-line great primer *black*) is the very same as that "used by all the printers in London to this day" (1730). Mr. Palmer adds his belief that these letters were actually cast from matrices struck by the punches of De Woorde, who was the first English printer in whose works we find the Roman letter, which he used with his black, or Gothic, to distinguish any thing remarkable, as we intermix *Italic* with the Roman. The fine old English, or black letter, used by printers in this country in the beginning of the sixteenth century, was imported, as were also other sorts, chiefly from Holland.

William Caslon, who died in 1766, holds a principal

place in the highest rank of English type-founders. He was bred to the original occupation of the celebrated Hogarth, namely, an engraver of ornaments on gun barrels, from which he proceeded to the manufacture of tools for bookbinders; and thence, by an easy step, in conjunction with the fortunate notice and encouragement of Bowyer, the celebrated printer, to the cutting of letters on steel for making matrices to cast types. Previous to the time of this first-rate artist and worthy man, English typography was indebted to Holland for many of its characters; but such were the elegant, and indeed almost perfect, specimens of the art which Caslon produced, that the types cast at the foundery in Chiswell Street were not only exported to the continent, but hardly surpassed in any part of the world.

The eccentric John Baskerville, of Birmingham, who died in 1775, distinguished himself by various improvements in printing and type founding. His letters were particularly fine and sharp; their beauty, too, was set off in his own office by the use of excellent ink, and paper of the best quality, so that the works printed by him fetch high prices. It is a somewhat curious fact, that, after the death of this individual, his widow, not meeting either with sufficient patronage to continue the foundery, or with a purchaser of the concern, in this country, sold the types to a literary society in Paris, where they were used in printing a splendid edition of the works of Voltaire.

The French have to boast the works of an improver of their typography, of no less celebrity than our countrymen — John Gottlob Immanuel Breitkopf, who died in 1794. His printing house and letter foundery acquired the reputation of being the most perfect in the world, not excepting those of the Society "de Propaganda" at Rome: it contained punches for four hundred alphabets. He designed the original punches of his letters on mathematical principles, and hence their beauty and accuracy. Breitkopf devised and perfected the method now largely practised, of printing musical

lines and characters with types; he also succeeded in forming types adapted to the Chinese characters, which had long been a desideratum. His foundery contained twelve furnaces, and employed from thirty to forty workmen. Didot, his countryman and contemporary, was likewise famous for the perfection of his types.

The principal type founderies are in London, Edinburgh, Glasgow, and Sheffield: the reputed establishment of Blake, Stephenson, and Co., of the latter place, having originated, many years ago, in the purchase of the matrices of the celebrated Caslon.

The operations connected with a type foundery may be enumerated generally as follows:— 1. Preparing the mould; 2. cutting the punches; 3. striking the matrix; 4. mixing and melting the metal; 5. casting; and 6. dressing the letters. The mould is a very ingenious, and somewhat complex contrivance: the two portions or halves, between which the types are actually cast, are of iron; but they are respectively attached to wooden backs, which render the whole convenient to hold, and at the same time prevent the hands from coming into contact with the metallic portions of the mould, which get heated during the progress of casting. The mould, as already stated, consists of two parts, — the upper part is shown by *fig.* 17., and the under part by

Fig. 17. *Fig.* 18.

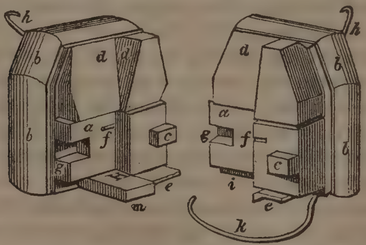


fig. 18. These two parts are so exactly fitted to each other, that, when properly placed together, a square funnel-shaped opening or mouth is formed for the more easy introduction of the melted metal, while a space re-

mains open down the middle, adapted to the form and size of the intended letter. Two projecting knobs adapted to corresponding grooves, and called gauges, allow the two halves of the mould to slide sideward a trifle, as the shank of the letter may be required greater or less; or, in other words, to suit all letters of the same fount, from an *i* to an *m*. The different parts of the mould are thus named:—*fig.* 18, 19. *a*, *a*, the carriage, the more elevated side of which is called the body; *b*, *b*, the wood, to which all the other parts are fastened, by means of an intermediate plate of iron; *c*, the gauge; *d*, the mouth and throat; *e*, the register; *f*, the nick; *g*, the groove; *h*, the hag; *i*, the stool; *k*, the spring or bow; *m*, the matrix.

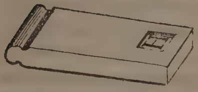
The utmost attention and skill are required to ensure perfect accuracy in the fitting of every part of the mould, and particularly that the letters may come out exactly square, and the faces stand at perfectly right angles with the sides; without which they would neither admit of being composed for use without starting when wedged together in pages, nor would they form, *en masse*, that absolutely even surface, so essential in good printing. The securing of these ends is called justifying the mould; and during the operation, a number of trial letters are cast, and examined by a variety of delicate measurements, until their perfect accuracy is ascertained.

The next business is to prepare the matrix, or that part from which the figure or letter on the end of each type is immediately derived, and upon the perfection of which, therefore, the beauty or otherwise of the letter exclusively depends. The original of every letter is a steel punch, the execution of the figured end of which requires peculiar delicacy in the application of the various small files, punches, and gravers employed. The form of the letter is, in the first place, delineated either with a pen and ink, or, when very minute, with the point of a needle; the interstices being afterwards cut out, and the outer parts filed away, leaving only the character itself in relief on the steel. Great nicety is required

to develope the letter properly and with exact symmetry of all its parts, so as that the removal of the superfluous metal should not be too inconsiderable or overmuch: if the latter, the type will not wear well; if the former, it will not print clearly, but give a blurred impression.

When the punch is cut, tempered, and found perfect, the next thing done is to strike the matrix. The matrix is a piece of copper, about an inch and a half long, and of a breadth proportionate to the size of the letter it is intended to receive: its shape will be better understood from the annexed cut (*fig.* 19.). The steel punch is carefully struck to a proper depth into the copper near the end, and thus forms the matrix, which is afterwards filed to the form represented; the surface being levelled, the bulging from the operation of the punch corrected, and cross nicks cut near the end farthest from the impression, which is afterwards slightly rounded. The mould and matrix being thus prepared, they are ready for the caster.

Fig. 19.



The metal used by the type founder is a composition consisting chiefly of lead and regulus of antimony, with a little tin, and sometimes other ingredients. The chief object of mixture is to obtain perfect fluidity, so that the counterpart of the matrix shall come away sharp and perfect; moreover, that the letters shall be hard enough to wear well, and stand to their work firmly, without at the same time becoming brittle: a type, however, will break sooner than bend. The ingredients and mixture of the metal differ in different establishments, and are generally kept secret; the stock meltings take place at certain seasons, under the inspection of the principal, when the metal is run into small ingots, and afterwards served out to the workmen as they may want it. It is melted for use in a small cast-iron pot, set in brick-work at a convenient height, and the fire so enclosed, that the workman is as little as possible annoyed by the heat and fumes. The number of these furnaces varies according to the extent of the establishment.

In proceeding to cast, the workman takes the two parts of the mould (*figs.* 17, 18.), and placing them together, the gauge *c* fitting exactly into the groove *g*, on each side respectively, an interior space is left up the middle of the mould, corresponding to the cubical body of the letter, and also answering exactly to the impression on the matrix *m*, which is inserted in a nick formed by the register *e*, and kept steadily in its place by the end of the spring *k*, being brought to the groove in the outside of the matrix, and pressing against it. Holding the mould firmly in his left hand, he takes from the iron pot, by means of a small ladle in his right hand, as much metal as will suffice to cast the letter, and, besides that, nearly to fill the throat or funnel *d d*. The instant the workman has poured the metal into the mould, he gives it a peculiar jerk or heave upwards, in order to expel in some degree the air, and drive the metal fully into the matrix. A great improvement has of late years been introduced into this department; instead of the open metal pot and the ladle, and the heaving just described, a close pot is used, in the cover of which is fixed a small iron forcing pump, with spout and handle overlaying the margin of the vessel. By means of this contrivance the work is amazingly expedited; a slight depression of the handle forces a jet of the molten metal through the proper orifice, to which the mouth of the mould is applied, the entire operation being only momentary. By removing the spring, the matrix is just drawn from the letter, which, on separating the parts of the mould, is thrown out to the heap on the work-bench. A single workman will cast 2000 or 3000 letters in a day.

In this state, each letter has a taper piece of metal or castable attached, which has been formed in the throat of the mould: these are carefully broken off by boys, after which the letters are ready for the further dressing. A boy, having his fore-finger defended by a little cap of leather, takes up the types one by one, and with singular rapidity rubs them on both sides upon a stone or smooth flat file laid on the board: they are then placed

side by side in long sticks or rulers, which on being firmly screwed together, the types form a solid series, and are easily smoothed on their edges, by passing over them a scraping tool similar in form to a razor blade. In these dressing sticks they are likewise bearded and grooved, as the operations are called: the first consists in shaving away a small portion of the shoulder of each letter next the face, and the other in cutting a small semicircular groove in the foot; both these removals of superfluous metal are effected by passing a light iron plane with great address along the line of types, while they are wedged in a line between two parallel pieces of wood. A small semicircular groove, similar to that planed in the foot, is cast in one edge of the letter, by means of the projection of the wire *f* in the mould. In some founts of letters there are two or three of these nicks: they form a continued gutter along the outside of a line of letters while in the composing-stick, and when none of them are in an inverted position.

There are some sorts, called kerned letters, in which a small portion of one type extends over the corner of another, as the tail of the italic *j*, and the beak of the *f*: these require greater care in the dressing. To obviate one difficulty in the joining of letters of this sort, between which, on account of their inclination, or bending parts, the space would be considerable, some of them are cast together, as *ff*, *fi*, *fl*. In some cases, the small roman f has been cast with the upper part a little bent backward, to allow of its setting up in the regular way. In the letter called script, or that which is cast to resemble writing, the inclination and bend of the characters is so considerable, as to require a corresponding deviation from the rectangular form in the body of the type. Hence, a transverse section of the metal forming the word *Bought of* would appear very different from that of the same words composed of similarly sized type of the ordinary Roman character.

As the trouble of setting up or composing with pes of the former description is much greater than

with the common sort, a great improvement has been introduced, by casting script on a square body, so as to allow of being set up by the compositors with the usual facility. A beautiful fount of this character, thus ingeniously devised, has lately been introduced by the firm last named above. Besides the letters themselves, points, figures, spaces, quadrats, &c. are cast of sizes to correspond; a complete series of these being called a fount.

The very large letters, impressions from which we frequently see in placards, were formerly called sand-letters, from their having originally been moulded and cast in sand. A method, however, of casting them in metal moulds in a similar manner to that which is practised with the smaller sorts, was devised by the late Mr. W. Caslon, and is now adopted in all type founderies. The matrices for these large characters are not made by striking with punches, as above described, but by cutting the design of the letter quite through a piece of brass about a quarter of an inch thick, and then closely rivetting it upon a back plate of the same metal. The mould also, instead of being held in the hand while the metal is poured in, is attached to two iron rods, and placed during the casting over brackets on the work-bench. Picture letters, when large, as well as a great variety of cuts used upon posting bills and otherwise, are cast in plaster-moulds by the process afterwards described. The largest black-face letters are probably those in occasional use by the English printers: a fount of the smallest letters known has been executed in France. It need scarcely be added that, between the two extremes of size just mentioned, the types in common use are graduated to the closest degrees of variation, and are distinguished in the trade by a corresponding diversity of appellations.

As immediately connected with this subject, must now be noticed the more modern invention of stereotype, and which differs from the important art above described mainly in this, that the letters, instead of being run singly in metallic matrices, are cast in plates comprising entire pages from plaster of Paris moulds. The

honour of this important invention has been claimed by Holland, and apparently with justice, so far as the fact of having cemented types together in pages can justify the claim. The Luchtmans of Leyden appear to have printed Bibles from stereotype plates of this description since 1711. The plan, however, of forming compact pages by soldering the bottoms of common types together by some melted substance, whether metal or mastic, is very different from that now in use; and certainly not less so the construction, about 1735, of some plates of copper used in printing the calendar to a prayer book, upon which our neighbours across the channel have founded a claim. It is in England that the art of stereotyping has been brought to perfection, if not actually first practised; and, therefore, we cannot, as Mr. Jameson has properly observed, think of yielding, on such pretensions as those adduced by Holland and France, the merit of the improvement in the invention, when, on this side of the water, we have positive names and dates of about the same period to show that the art was then practised in this and the sister kingdom; by Mr. Ged of Edinburgh, in 1725, and by Mr. Fenner and Mr. James of London, who absolutely cast plates for Bibles and prayer-books in the University of Cambridge in the year 1729-30.

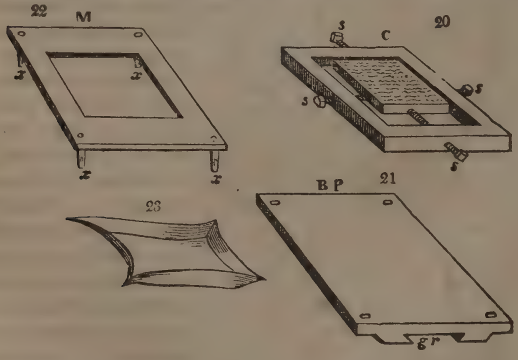
In the ordinary method, as already intimated, the types are composed into a page as usual: upon this plaster of Paris in a liquid state is poured, so as to form a mould exhibiting a perfect *fac-simile* of the face. When dry, and surrounded with a proper raised margin, this mould is lowered into a vessel containing type metal in a melted state, and which, filling every cavity, forms, when the mould has been removed and become cool, a solid page of letters, which, after being dressed on the back until there only remains a plate sufficiently thick to keep the whole together, is attached either to a wooden slab or a composition body about $\frac{5}{8}$ths of an inch thick: in this state the pages are ready for printing. The advantages of stereotype are: 1. That a work thus prepared, and once rendered absolutely correct, is afterwards in no danger

of contracting errors, either through negligent correction of the proof sheets, the dropping out of letters or words, or other causes: 2. The plates once cast and rendered perfect may be used for printing only such an edition in the first place as may enable a publisher to try the chances of sale without risking a large amount in paper and pressmanship, or even losing interest of money sunk upon a stock of work accumulated with reference to certain but remote demand: 3. Economy of metal; for, although works in ordinary type may be, and sometimes are, "kept standing," as the phrase is, they are not only liable to accidents by the breaking of matter, or the dropping out of letters; but the expense of the type is too heavy to allow of this practice to any considerable extent, either as to number of works or books of a long number of pages. The volume which the reader has now before him, as well as the other volumes of the *Cabinet Cyclopædia* has been printed from stereotype plates. Of the fifty-four volumes of this work now (April, 1834) published, any one can be reprinted — and nearly all have been repeatedly reprinted — at no further expense to the proprietors than the cost of *press-work;* which is the most inconsiderable item in an ordinary printing account. Without the possession of stereotype plates, it would have been necessary to keep on hand a stock of from 100,000 to 120,000 volumes, involving a large expense for warehousing, besides the loss of interest on capital. Instead of this, a stock of about one third of the above amount is at present sufficient; in addition to which, however, there is a stock of above 20,000 stereotype plates.

It is sometimes objected against stereotyping, that it perpetuates errors, and removes the opportunity for improvement which every successive edition of a work printed from moveable types offers. This objection has not, however, all the force which at first view it appears to have. Stereotype plates are not unalterable. Letters, words, and even sentences may be cut from a page, and others soldered in, provided the substituted matter can be made to fill the same space as

the matter obliterated. Pages may be broken up and replaced by new ones, provided the same number of pages be supplied. Even this condition is not absolutely necessary, since there are contrivances for marking the succession of pages practised by printers, which will enable an author to enlarge or contract any part of a stereotyped work.*

In 1818, Mr. Applegath obtained a patent for improvements in the manufacture of stereotype plates, which consisted in the formation of a metallic mould or matrix, and in casting from or striking a plate with the same by the following ingenious process: — The letters or types, or metallic blocks or other ornaments from which the matrix is to be made, are composed, or, as the printers term it, set up into a page in the ordinary manner, care being taken to use the high spaces and quadrats commonly employed in stereotyping, as also metal furniture or bars round the page. The page, thus made up, is then placed in the metal frame or chase C



* In cases where one part of a work is of a nature not to require any change in successive editions, while another part, depending on progressive events, must require, from time to time, enlargement and modification, the former part may be stereotyped, and the latter printed from moveable type. An instance of the successful adoption of this expedient is presented in a small descriptive (historical) Treatise on the Steam-engine, by the editor of this Cyclopædia, the first nine chapters of which are stereotyped. Five editions have been printed; and in each the work has kept pace with its subject.

(*fig.* 20.): it is then firmly fastened by the screws *s*, *s*, *s*, *s*, and the intervals between the types and the sides of the chase are to be filled up with pieces of metal or wood. The page or chase is now laid upon the metal plate B P (*fig.* 21.), which is termed the back, and made perfectly true. The frame M (*fig.* 22.), which is called the moulding frame, is then placed upon the chase, so that the type occupies the open space. The frame M (*fig.* 22.) is furnished with pins *x*, *x*, *x*, *x*, which pass through corresponding holes in the back plate, where they are fastened either with screws or keys.

Fig. 24.

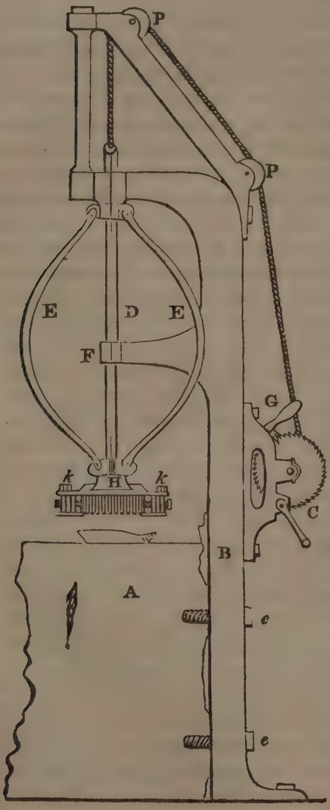


Fig. 24. represents the striking or casting apparatus. A is a solid block of wood, to which the iron support or pillar B is fixed with screws *e*, *e*; at C is a wheel and pinion, from the barrel of which a rope passes over the pullies P, P, to wind up the striking rod D; the ratchet plate at C is furnished with a catch or click G, which can be easily

disengaged; E E are two strong bow-springs, which are compressed by winding up the striking rod, and which cause by their reaction the striking rod to descend upon the wooden block: these springs are so arranged that they act forcibly against the block after the descent of the striking rod: F is a guide bearing, which causes the striking rod to ascend and descend in a perpendicular direction. The lower part of the striking rod D is furnished with a piece of iron, which has a projecting dove-tail H, to fit the groove *g r*, in the plate B P (*fig.* 21.): *k*, *k* indicate the nuts or keys which fasten the pins of the frame M, when passed through the holes of the back-plate just mentioned. The wooden block may be furnished with a small flap or screen of thin plate iron, to protect the workman from the splashing of the metal.

The mode of using this apparatus, and of forming a matrix therewith, is as follows: the chase, type, moulding frame, and back plate, being attached by means of the groove and dove-tail to the lower part of the striking rod, the rod is wound up, by means of the wheel and pinion, to about the distance of eight inches from the wooden block. The workman then takes a small quantity of metal, or an alloy, composed of twenty parts lead, two parts regulus of antimony, and one or two more parts bismuth, in a state of fusion, and pours it into a piece of dry cartridge paper, loosely folded up as a box or trough, as shown in *fig.* 23., and places it upon the wooden block immediately under the striking rod D: he gently raises the corners of the paper, and moves the fluid metal toward the centre, that it may attain the same degree of heat in every part; it should also be a little thicker or heaped towards the centre. As it becomes cool, and just in the point between fusion and fixity, the workman nimbly disengages the catch or pall of the ratchet wheel, when the striking rod instantly descends by the action of the springs, and causes the type and moulding frame to form an impression on the semifluid metal, in the same manner as sealing-wax

receives the impression of the seal. If the operation be well performed, a perfect *creux* impression of the type is formed in the metal, which thus becomes a metallic mould or matrix.

The back plate and chase, having the type and matrix adhering thereto, are then removed from the striking rod, and the matrix is disengaged from the type by gently raising the moulding frame. If the type has not been originally made with much bevil, it will adhere a little to the matrix: this may in some measure be prevented by slightly brushing the face of the type over with a little dry soap and red ochre: but type that has been cast from a shallow matrix, with as much bevil as possible, is to be preferred.

The next operation to be performed is the striking or casting a plate from the metallic mould, which is done in the following manner. The mould is to be placed upon the plate B P (*fig* 21.), and the moulding frame laid over it, and fastened with the pins and keys, as before described; the plate is then attached to the striking rod, and the operation of striking the plate is precisely the same as that of striking the mould, namely, in the semifluid or half-set metal. The plate metal may be the same as the ordinary type metal, or an alloy of one part regulus of antimony, to three, four, or five parts of lead. When the operation is well performed, a perfect plate or fac-simile of the original page of type is produced. The plate may be disengaged from the mould by gently raising the moulding frame: if any difficulty occur in disengaging the mould from the type, it will be necessary, as before mentioned, to brush the mould over with dry soap and red ochre previous to casting the plate. The back of the plate may then be turned in a lathe to make it true and parallel to the face. The ordinary ornamental impressions on the back of bank notes, are from plates produced by this process from engravings exhibiting relief and *creux* work mixed together.

CHAP. VIII.

COPPER MINES AND SMELTING.

PECULIARITY AND USES OF COPPER. — EARLY NOTICES OF THIS METAL. — ANCIENT COPPER MINES WHICH SUPPLIED GREECE, ROME, AND OTHER COUNTRIES. — ABORIGINAL BRITONS HAD IMPLEMENTS OF COPPER. — ENGLISH COPPER. — CORNWALL. — HISTORY OF THE COPPER MINES IN THAT COUNTY. — FLUCTUATIONS OF THE TRADE. — RECENT PRODUCE AND EXPORTATION. — GREAT VARIETY OF COPPER ORES. — SUBSTANCES IN WHICH CONTAINED. — AVERAGE PRODUCE. — ORES MOSTLY SMELTED IN WALES. — DESCRIPTION OF CALCINING AND SMELTING FURNACES. — CALCINATION OF THE ORES. — MELTING. — CALCINATION OF COARSE METAL. — REMELTING. — CALCINATION AND REMELTING OF FINE METAL. — REFINING OR TOUGHENING. — INGOT AND GRANULATED COPPER. — DISMAL APPEARANCE OF THE SMELTING ESTABLISHMENTS. — ATTEMPT TO CORRECT THE NOISOME EFFECTS OF SMOKE FROM THE HAFOD WORKS. — PRODUCTION OF COPPER, VIA HUMIDA. — PRECIPITATION OF COPPER BY MEANS OF IRON IN STREAM WORKS.

Copper, when pure, is of a singularly red colour, exceedingly malleable and ductile: it admits of being hammered, when at a red heat, in which respect it differs from brass: as compared with iron, it is remarkably incorrodible, nearly as tenacious in structure, but less hard. These and some other qualities render copper of inestimable value to the manufacturer. The quantity consumed in this country is, accordingly, very great, particularly in the plating of ships' bottoms, the coinage of the lowest description of money, the innumerable purposes of the coppersmith, and for conversion into brass.

This useful metal was well known to the nations of antiquity; and the mention of brass, as specifically distinguished from gold, silver, and iron, which occurs in

ancient authors, must often be understood as having reference to copper, either in its pure state, or as alloyed with tin, rather than to any compound exactly answering to our brass. Such is undoubtedly the meaning of the word as occurring in Scripture: for example, in that passage which describes "a land, whose stones are iron, and out of whose hills thou mayest dig brass," Deut. viii. 9. Brass, being a factitious metal, the base of which is always copper, the latter metal alone, whether afterwards transmuted or not, must have been the mineralogical product of Judea alluded to in the text, as well as in several other instances where the same term occurs. Although the reduction of the ores of copper is one of the most tedious of metallurgic operations, as in the mine they are among the refractory, there seems no reason for supposing that this stubborn resistance to tools and fire materially retarded the success of very early works, contrived for the extracting of so valuable a metal.

In the book of Genesis, Tubal Cain is mentioned expressly, as "an instructor of every artificer in brass and iron;" but to what extent the knowledge and practice of the art of working in metals was carried in those early times, we have but very imperfect means of judging. That the Hebrews would work any mines which they might discover in their own country cannot be doubted; that they trafficked with other nations, for the precious metals at least, is certain. It is probable they might obtain copper, and even brass, from Egypt, in which country Moses is supposed to have acquired his knowledge of metallurgy. Mr. Jacob, whose elaborate work on the precious metals it is hardly possible to praise too highly, justly states that the chief sources of the wealth of the Pharaohs were the mines of the neighbouring countries of Nubia and Ethiopia, which were productive of copper or brass in great abundance before iron was known in Africa. According to the testimony of Agatharchidas of Cnydus, who wrote about 170 or 180 years before our era, the abundance of

brass was such, that it formed the chief part of the domestic furniture, as well as of the chariots, the swords, the bows and the arrows in use, in a prior age. The mines which produced the copper yielded also gold, which the Africans separated from the less valuable metal. There is an exact and almost technical description of those mines by an eye-witness, who visited them in the reign of the fourth Ptolemy. "They are," he says, "near the mountain Altaki, not far from the ancient Berenice Lauchrysos, in latitude 22° north. They were worked by a numerous body of people, including men, women, and children, to each of whom a portion of labour was assigned, correspondent to their strength and skill. The discovery of them was made by the kings of the ancient race."

The operations in the mines of Nubia were interrupted by the invasion of the Ethiopians, who took possession of them, and afterwards by the Medes and Persians. In the passages of the mines were found many tools of brass, iron being then unknown, and vast masses of human bones of people who had been buried in the ruins. The extent of the subterranean galleries is so great that they must almost have reached to the sea.

The earliest knowledge which the Greeks possessed of the working of the ores of this metal is attributed by Strabo to Cadmus, the Phœnician, who, arriving with other emigrants in Greece, in the year 1594 before Christ, opened the first mine of copper in the mountain of Langæus, in Thrace. Strabo likewise mentions Eubœa as producing excellent copper, at an early period, though in his time it seems the mines were exhausted. There were likewise very ancient copper mines in the island of Cyprus, which continued to be worked in the time of the Romans, and traces of which have been observed by travellers in the middle ages. Homer, in his Odyssey, represents the Greeks as purchasing copper from Temesa, an island near Upper Italy, by which appellation it has been thought the island of Cyprus might be

meant. It may be added that Sicily and the Lipari Islands were celebrated in times of antiquity for the brass which they afforded.

According to Macrobius, quoted by Jacob, the Etrurians, by their knowledge of mining, first obtained copper, and afterwards iron; and it is remarkable, as indicating one of the primitive uses of the former metal, that, when the boundaries of their city were marked out, it was done with a ploughshare of copper or bronze; and, moreover, it was the custom of the priests to have their hair cut with knives or razors made of copper, though it does not appear that, like some other of the ancient tribes, they had acquired the art of hardening it by a mixture of tin. "These people supplied Rome with the copper from which was coined all the money which circulated in Rome, through several succeeding centuries."

The use of copper among some of the northern nations of Europe, in the fabrication of weapons, at a period and under circumstances when steel appears to have been more precious than gold, has been illustrated in Denmark by the opening of many Scandinavian tumuli, of very remote ages, and from which have been collected specimens of knives, daggers, swords, and implements of industry, which are preserved and arranged in the museum at Copenhagen. There are tools of various kinds, formed of flint or other hard stone, in shape resembling our wedges, axes, chisels, rammers, and knives, which are presumed to have been those first invented. There are swords, daggers, and knives, the blades of which are of gold, whilst an edge of iron is attached for the purpose of cutting. Some of these tools and weapons are formed principally of copper, with edges of iron; and in many of the implements, the profuse application of copper and gold, when contrasted with the parsimony evident in the expenditure of iron, seems to prove that at the unknown period, and among the unknown people who raised these tumuli, which

antiquarian search has lately explored, gold as well as copper were much more abundant products than iron.

Copper swords, but more frequently celts, apparently cast from a mixture of that metal with tin, have been dug up in Ireland: brazen weapons, of ancient formation, have likewise been found in this country, and are thought by Camden to be of British manufacture; but at what period, or to what purposes these were applied, or whether they were in reality the product of our native mines, we are almost entirely ignorant. The earliest inhabitants of this island of whom we have any account, certainly wore upon their arms and legs massive rings, probably of this metal, but whether it was of their own smelting, or obtained by barter from their visitors, is not clear, though Cæsar says expressly, that the Britons made use of imported copper.

Copper has been found with the other mineral strata of this country in several places. A little has been met with in Derbyshire; and there was formerly a very famous mine at Ecton in Staffordshire, belonging to the duke of Devonshire, and from which immense quantities of rich ore were derived previously to 1770. The main body, however, of the mineral treasure in that spot, is supposed to have been long since exhausted, and that the subsequent workings have only been upon branches of it. At present, that interesting country, from whence British tin has been drawn through so many ages, is the chief source of that amazing quantity of copper ore, which is constantly in the home market; in the dates, however, of the earliest periods of working these coexistent treasures of this metalliferous region, "the history of Cornish copper," says Mr. Warner, "is as a mushroom of last night, compared with that of tin. Lying deep below the surface of the earth, it would be concealed from the enquiries of human industry, till such time as natural philosophy had made considerable progress, and the mechanical arts had nearly reached their present state of perfection; for, notwithstanding tin in Cornwall seldom runs deeper

than fifty fathoms below the surface, good copper is rarely found at a *less* depth than that." Accordingly, as this writer remarks, we do not find that any regular researches were made for copper ore in Cornwall till the latter end of the fifteenth century, when a few adventurers worked, in an imperfect manner, some insignificant mines, probably with little use to the public, and little profit to themselves. Half a century afterwards, in the reign of Elizabeth, though the product of the mines would be naturally greater than before, from the increased industry of the people, and the improved state of the arts, yet little advantage seems to have been derived to the county of Cornwall at large from the working of its copper. Mr. Carew hints at the small profits made from it in his time, and assigns as a cause of it, the ignorance in which the mine proprietors were kept by the merchants with respect to the uses and application of the metal. In the next reign, however, all this mystery was dispersed; the mines were inspected, their value determined, and a system of working them to greater advantage introduced.

This beneficial change was effected by the vigilance of Mr. Norden, Cornish surveyor to the prince of Wales, who, having observed that certain artful practices were adopted to conceal the real value of the copper produced from the mines, wrote a letter to king James I., communicating the frauds, and recommending that means might be adopted to prevent them in future. The general confusion, however, into which the kingdom was thrown in the time of Charles I. checked the copper mines of Cornwall; nor were they characterised by peculiar activity and proportionate profit till after the Revolution, when a company of gentlemen from Bristol, paying a visit of speculation to them, made a general purchase of their produce at various prices from 2*l.* 10*s.* to 4*l.* per ton. The bargain proved to be highly advantageous to the purchasers, a secret that quickly transpired, and induced another company from the same place, a few

years afterwards, to covenant with some of the principal Cornish miners to purchase all their copper ores, at a stated low price, for a certain term of years. This free demand would naturally sharpen the attention, and spur the industry of the mine proprietors: their views began to extend, and prospects of great fortune to open upon them; though, it is strange to add, such was still the backward state of mineralogy, that the yellow copper ore, which is at present so valuable, was at the time above mentioned considered of no importance, called *poder*, that is, *dust*, and put aside as mundic.

In the year 1712, the copper manufacture of England was brought to great perfection, inasmuch as this was expressly declared to be the state of the trade, in a statute of the twelfth of queen Anne, for making perpetual the act made in the thirteenth and fourteenth years of the reign of king Charles II., entitled "An Act for the better Relief of the Poor of this Kingdom," enacting "that any of his majesty's subjects may export from England copper bars imported from foreign parts; and upon exportation, shall draw back all duties, or vacate the securities, saving the half of the old subsidy, as is usual in other commodities," was now revived in the following words: viz., "which clause being expired, and forasmuch as the copper manufacture of this kingdom is brought to such perfection, that there is more made than can be expended here and in the plantations; be it therefore enacted, &c., provided, nevertheless, that no drawback be allowed on the exportation of any copper, but such as shall be imported from the East Indies and the coast of Barbary only."

In the reign of George I. the Cornish mining system in general, and particularly as it related to copper, was still further improved. A Mr. John Costar was the person to whom the country is indebted in this respect. Being an excellent metallurgist, and a good natural philosopher and mechanic, he undertook the draining

of some considerable mines, and executed the attempt with success. He then introduced a new system of dressing and assaying the ore, and improved upon the old machinery, and invented new engines. In short, he seems to have given a new character to the copper concerns of Cornwall, and been the father of many of the processes which render them so profitable as they are at present. The state of the copper market from this period for the next fifty years, will evince the importance in a national as well as provincial point of view, to which it had then attained: — The quantity of ore sold from 1726 inclusive, to the end of 1735, was 64,800 tons, at an average price of 7*l.* 15*s.* 10*d.* per ton, amounting to 473,500*l.*, which must have been yearly 47,350*l.* From 1736 inclusive, to the end of 1745, 75,520 tons of copper ore were sold at 7*l.* 8*s.* 6*d.* average price, the amount 560,106*l.* in the gross, and 56,010*l.* yearly. From 1746 inclusive, to the end of 1755, the quantity sold was 98,790 tons, at 7*l.* 8*s.* the ton, the amount 731,457*l.*; annually 73,145*l.* From 1756 inclusive, to the end of 1765, the quantum sold made 169,699 tons, at the average price of 7*l.* 6*s.* 6*d.*, amounting to the sum of 1,243,045*l.*, and 124,304*l.* yearly. Lastly, from 1766 to the end of 1777, 264,273 tons of copper ore were disposed of at 6*l.* 14*s.* 6*d.* per ton, amounting in all to 1,778,337*l.*, which must have returned 177,833*l.* every year of the last ten.

The foregoing calculations are from Pryce's mineralogy: according to Mr. Warner, however, the quantity of copper ore raised annually, since the time when the above account closes, has been larger in every successive year, till 1808, when the diminution of the demand lowered the price, and lessened, of course, the number of speculations. The following schedule of the productions of four years preceding 1808, in copper ore, fine metal, and the sums for which it sold, afford an interesting view of this branch of the trade of Cornwall previous to the check: —

Copper Ore.		Fine Copper.		£
1803.—54,381 tons,	containing	5,351,	sold for	560,144.
1804.—64,597	——	5,373,	—	571,123.
1805.—80,043	——	8,416,	—	862,295.
1807.—73,405	——	6,827,	—	630,267.

The depression which ensued in the following year was attributable to the blasting influence of a protracted war, conjointly with an increased produce of the Cornish mines, and large importations of foreign copper. The very high price to which the metal had risen, both induced and enabled the miners to speculate more largely than they had hitherto been accustomed to do. The consequence of this was, a supply more than sufficient for all the demands of the British market, and a fall in the price of the ore naturally followed. Unfortunately for Cornwall, just at the period of this depression, very large quantities of copper from South America were taken by the British cruisers, and the prizes brought to England; whilst about the same time, considerable importations of the same article arrived from Lima and other places in South America, the speculations of British merchants to these parts under licences from the British and Spanish governments. In 1808, the year above alluded to, the average price of copper had fallen 20*l.* per ton as compared with the average price of the preceding twelvemonth. In the year following, however, there was an average increase of 40*l.*, the price being, in relation to the whole amount sold, 143*l.* 12*s.* per ton: it has never been so high since; and once, namely, in 1816, it fell to 98*l.* 13*s.* the ton. Mr. M'Culloch gives the following details relative to the recent state of the British copper trade, on the authority of Mr. Pascoe Grenfell, a gentleman very largely engaged in it:—" The quantity of copper produced during last year (1829) in Cornwall, from ores raised in that county, exceed 10,000 tons of pure metal; and if to this be added what has been produced in Wales, in other parts of England, and in Ireland, the whole quantity of fine orpure metal produced in the united king-

dom, in 1829, may be fairly stated at 12,000 tons." On the same authority we are told, that the quantity of British copper exported in the above year, amounted, according to an account laid before the House of Commons, to 7976 tons of fine metal, to which adding the exports of foreign copper, the total export was 8817 tons. The copper imported is always intended for re-exportation. The value of the 12,000 tons of copper produced in the united kingdom, as above stated, at 90*l.* per ton, amounts to 1,080,000*l.* Mr. Grenfell, however, elsewhere notes the average standard price of copper as 109*l.* 14*s.* per ton in 1829.

Of tin ores there are hardly more than four or five different sorts; while of those containing copper the varieties are innumerable. In the magnificent collection of native minerals to be seen at Menabilly in Cornwall, the seat of the Rashleighs, there are, amongst beautiful specimens of almost all other kinds, nearly a thousand varieties of copper ore. In most instances the Cornish copper mines are carried to a great depth, though there is nothing like uniformity in this respect. Masses of native copper have been met with in different parts of the world; in Cornwall and elsewhere, it is sometimes found on the sides of fissures in thin films, deposited by the impregnated water from the lodes or veins. Veins of copper are frequently discerned in cliffs that are laid bare by the sea; but the most encouraging symptom of a rich ore is an earthy ochreous stone, called *gossan*, which is of a ruddy colour, and crumbles like the rust of iron. Another promising indication is, when the ground is inclinable to an easy, free-working blue *killas*, intermixed with white clay. A white crystalline stone is likewise regarded as very retentive of yellow copper. The ore, as already intimated, does not lie at any particular depth, but it is a general rule, that when copper is discovered in any fissure, the lode should be sunk upon, as it commonly proves best at some distance below the surface. The lodes both of tin and copper appear most frequently in the vicinity of

the granite, which is called, in the language of the miners, their "country."

The matrices of copper are not only very numerous, but several of them so hard as to render the separation of them from the native mass a work of the utmost difficulty, and one to which the explosive force of gunpowder, and picks and chisels of the best steel, are almost indispensable. The variety presented in the appearance and quality of the ore is only equalled by the difference which exists in the market price of the produce of the several mines. The ores are disposed of to parties engaged in smelting works, at prices according to the estimated richness of each sort. Taking up a casual notice of the sales at Truro in the first quarter of the year 1832, it appears that, for forty-two lots, the produce of fourteen mines named, and amounting collectively to 3048 tons, the prices varied from 1*l.* 5*s.* to 11*l.* 5*s.* 6*d.* per ton.

Besides the ores smelted in the vicinity of the mines, vast quantities are transferred, for reduction to the metallic state, to Bristol, Birmingham, and especially to South Wales. The following interesting account of the processes of smelting copper, as conducted at the celebrated Hafod works, near Swansea, was written by J. H. Vivian, esquire, one of the proprietors, and originally printed in the Annals of Philosophy. The ores smelted in these works are raised partly in Cornwall, and partly in Devon; they consist chiefly of yellow copper ore, or copper pyrites, and the grey sulphuret of copper; the former compounded of sulphur, iron, and copper in nearly equal proportions; the latter yielding about 80 per cent. of metal. Yellow ore, which is by far the most abundant, is usually accompanied by iron pyrites, or sulphuret of iron. The earthy minerals that occur in these metallic substances are chiefly silicious, although in some mines the veins are of an argillaceous nature; while in others they contain fluor-spar, or fluate of lime. Thus the component parts of the Cornish copper ores, as prepared for smelting, may be said to be

sulphur, copper, iron, and from 60 to 70 per cent. of earthy matter. To these may be added, as accidental, tin and arsenic: the average produce of copper may be stated at 8½ per cent.

The ores are conveyed from Cornwall to Wales to be smelted, on account of the supply of fuel, as not only carrying the smaller quantity to the greater — the ore to the coal — but because the vessels load back coal for the use of the engines of the mines. The principal smelting works are situated on the navigable rivers of Swansea and Meath. The processes in a copper work are simple; they consist of alternate calcinations and fusions. By the former, the volatile matter is expelled, and the metals previously combined with the copper oxidised, the general fusibility of the mass being thereby increased. The furnaces in which these operations are performed are reverberatory, and of the usual construction. The substance to be acted on is placed on the body of the furnace or hearth, which is separated from the fireplace by a bridge of bricks about two feet in thickness. The flame passes over this bridge, and reverberating along the roof of the furnace, produces the required temperature, and escapes with any volatile matter that may be disengaged from the ore through a flue at the opposite extremity of the furnace, which flue communicates with a perpendicular stack or chimney.

These furnaces are of two descriptions, varying in their dimensions and internal form. The calcining furnaces, or calciners, are furnished with four doors or openings, two on each side the furnace, for the convenience of stirring the ore, and drawing it out of the furnace when calcined. They vary in their dimensions, but are commonly from 17 to 19 feet in length from the bridge to the flue, and from 14 to 16 in width; the fireplace from 4½ to 5 feet across by 3 feet.

The melting furnaces are much smaller than the calciners, not exceeding 11 or 11½ feet in length by 7½ or 8 feet in the broadest part; the fireplace is larger in proportion to the body of the furnace than in the

calciner, being usually from $3\frac{1}{2}$ to 4 feet across, and 3 or $3\frac{1}{2}$ feet wide, as a high temperature is required to bring the substances with as little delay as possible into fusion. These furnaces have only one door, which is in front. The annexed sketches represent plans,—*fig.* 25. of a calciner, *fig.* 26. of a melting furnace: *a*,

Fig. 25.

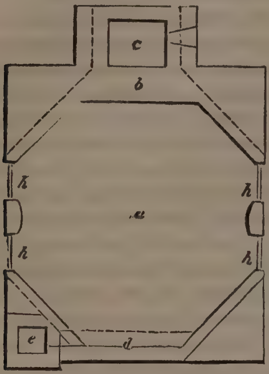


Fig. 26.

hearth, or body of furnace; *b*, bridge; *c*, fireplace; *d*, flue; *e*, stack, or chimney; *f*, tapping hole; *g*, skimming hole in melting furnace; *h h h h*, stirring doors in calciner.

Process I.—*Calcination of the Ore.* The copper ores, when discharged from the vessels in which they are brought from Cornwall, are wheeled into yards or plots contiguous to the works, and there deposited, one cargo over the other, so that, when cut down perpendicularly, to be carried to the furnaces, a tolerably general mixture is formed. This is always desirable in a smelting work, as the ores being of different qualities and component parts, the one acts as a flux to the other. The ore in the yard is weighed over to the calciner-men in boxes, containing each 1 cwt. These are carried on men's shoulders to the calciners, and emptied into iron

bins or hoppers, formed by four plates of cast iron tapering to the bottom, placed over the roof of the furnace, and supported by wrought iron frames resting on its sides: two of these bins are usually placed over each calciner, and nearly opposite the side doors, so that the charge of ore when let into the furnace may be conveniently spread, which is done by means of long iron tools, called stirring rabbles.

This charge of ore usually consists of three to three and a half tons; it is distributed equally over the bottom of the calciner, which is made of fire bricks or square tiles. The fire is then gradually increased, so that towards the end of the process, which lasts twelve hours, the charge is drawn out through holes in the bottom of the calciner, of which there is one opposite to each door; and, falling under the arch of the furnace, remains there till it is sufficiently cool to be removed, when water is thrown over it to prevent the escape of the finer metallic particles. It is then put into barrows and wheeled to the proper depôts: in this state it is called calcined ore. If the process has been well conducted, the ore is black and powdery.

Process II.—*Melting of the calcined ore.* The calcined ore is delivered, as in the raw state, to the workmen, in boxes containing 1 cwt each; the charge is deposited in the same manner in a bin placed on the top of the furnace, and from thence passed into the interior as required. When the charge is let down and spread over the bottom, the door of the furnace is put up and well luted. Some slags from the fusion of the coarse metal or sulphuret are added, not only on account of the copper they contain, but to assist the fusion of the ore, being chiefly composed of oxide of iron.

After the furnace is charged, the fire is made up, and the main object of the smelter is to bring the substances into fusion; it is, therefore, in this respect, different from the calcining process. When the ore is melted, the door of the furnace is taken down, and the liquid mass well rabbled, or stirred, so as to allow of the com-

plete separation of the metallic particles from the slags or earthy matters, and to get the charge clear of the bottom of the furnace, which is made of sand, and soon becomes impregnated with metal. The furnace being ready, that is, the substances being in perfect fusion, the smelter takes an iron rabble, and skims off, through the front door, the sand or slags, consisting of the earthy matters contained in the ore, and any metallic oxides that may have been formed, which being specifically lighter than the metals in the state of sulphuret, float on the surface. When the metal in the furnace is freed from slags, the smelter lets down a second charge of ore, and proceeds with it in the same manner as with the first; and this he repeats until the metal collected in the bottom of the furnace is as high as the furnace will admit of without flowing out at the door, which is usually after the third charge; he then opens a hole, called the tapping hole, in the side of the furnace, through which the metal flows into an adjoining pit filled with water. It thus becomes granulated, and collects in a pan at the bottom of the cistern, which is raised by means of a crane: it is then filled into barrows, and wheeled to the place appointed for its recep-ion.

The slags, received into moulds made in sand in front of the furnace, are removed after each charge, and wheeled out of the work to the *slag-bank*, where they are broken, and carefully examined; any pieces found to contain particles of metal, are returned to the smelter to be remelted, and unless the slag is very thick and tenacious, the copper which they may contain is found at the bottom: what is clean or free of metal is rejected. These slags are composed of the earthy matters contained in the ore, and the oxides of iron and other metals that were mixed with the copper. The oxide of iron gives them a black colour; the silex or quartz remains in part unfused, and gives the slags a porphyritic appearance.

In this process, the copper is concentrated, and a

mass of stuff with which it was combined in the ore got rid of. The granulated metal usually contains about one third of copper; it is thus four times as rich as the ore, and must consequently have diminished in bulk in the same proportion: its chief component parts are sulphur, copper, and iron. The men work round the twenty-four hours; and commonly melt in this time five charges: under favourable circumstances, as fusible ore, strong coal, furnace in good repair, they even do six charges: they are paid by the ton.

Process III.— *Calcination of the coarse metal.* This is conducted in precisely a similar manner to the calcination of the ore: the charge is nearly of the same weight; but, as it is desirable to oxidise the iron, which is more readily effected in this process than in the ore calciners, where it is protected from the action of the air by the earthy matters with which it is combined, the charge remains twenty-four hours in the furnace, and during that time is repeatedly stirred and turned. The heat during the first six hours should be moderate, and from that time gradually increased, to the end of the operation.

Process IV.— *Melting the coarse metal after calcination.* This is performed in furnaces exactly similar to those in which the ore is first melted, and with the calcined metal are melted some slags from the last operations in the works which contain some oxide of copper, as likewise pieces of furnace bottoms impregnated with metal: the chemical effect which takes place is, that the oxide of copper in the slags becomes reduced by a portion of the sulphur, which combines with the oxygen, and passes off as sulphurous acid gas, while the metal thus reduced enters into combination with the sulphuret. That there may be a sufficient quantity of sulphur in the furnace to promote these changes, it is sometimes necessary, when the calcined metal is in a forward state, to add a small quantity of raw or uncalcined metal, so that a clean slag may be obtained; the slags from this operation are skimmed

off through the front door, as in the ore furnaces. They have a high specific gravity, and should be sharp, well melted, and free from metal in the body of the slag. After the slag is skimmed off, the furnace is tapped, and the metal is suffered either to flow into water, as before, or into sand-beds, according to the modes of treatment it is to be subjected to in subsequent operations. In the granulated state, it is called fine metal; in the solid form, blue metal, from the colour of its surface. The former is practised when the metal is to be brought forward by calcination: its produce in fine copper is about sixty per cent.

Process V.—*Calcination of the fine metal.* This is performed in the same manner as the calcination of the coarse metal.

Process VI.—*Melting of the calcined fine metal.* This is performed in the same manner as the melting of the coarse metal; the resulting product is a coarse copper, from eighty to ninety per cent. of pure metal.

Process VII.—*Roasting.* This is chiefly an oxidising process: it is performed in furnaces of the same description as the melting furnaces, although distinguished by the appellation of roasters. The pigs of coarse copper from the last process are filled into the furnace, and exposed to the action of the air, which draws through the furnace at a great heat: the temperature is gradually increased to the melting point, the expulsion of the volatile substances that remained is thus completed, and the iron or other metals still combined with the copper are oxidised. The charge is from 25 to 30 cwt.; the metal is fused toward the end of the operation, which is continued from twelve to twenty-four hours, according to the state of forwardness when filled into the furnace, and is tapped into sand-beds. The pigs are covered with black blisters, and the copper in this state is known by the name of blistered copper: in the interior of the pigs the metal has a porous honeycombed appearance, occasioned by the gas formed by the ebullition which takes place

in the sand-beds on tapping. In this state it is fit for the refinery, the copper being freed from nearly all the sulphur, iron, and other substances, with which it was combined. In some works the metal is forwarded for the refinery, by repeated roastings, from the state of blue metal: this, however, is a more tedious method. The oxidising processes are greatly assisted by a contrivance, the patent for which was purchased by Messrs. Vivian of Mr. Sheffield the inventor; the object of which is, to keep a constant stream of fresh air passing over the metal by means of a channel formed in the bridge, communicating by holes with the external air, and with the interior of the furnace.

Process VIII. — *Refining and toughening.* The refining furnace is similar in construction to the melting furnaces, and differs only in the arrangement of the bottom, which is made of sand, and laid with an inclination to the front door instead of to one side, as is the case in those furnaces from which the metal flows out; the refined copper being taken out in ladles from a pool formed in the bottom near the front door. The pigs from the roasters are filled into the furnace through a large door in the side. The heat at first is moderate, so as to complete the roasting or oxidising process, should the copper not be quite fine. After the charge is run down, and there is a good heat on the furnace, the front door is taken down, and the slags skimmed off. An assay is then taken out by the refiner with a small ladle, and broken in the vice; and from the general appearance of the metal in and out of the furnace, the state of the fire, &c. he judges whether the toughening process may be proceeded with, and can form some opinion as to the quantity of poles and charcoal that will be required to render it malleable, or, as it is termed, bring it to the *proper pitch.* The copper in this state is what is termed *dry.* It is brittle, is of a deep red colour inclining to purple, an open grain, and a crystalline structure. In the process of toughening, the surface of the metal in the furnace is first well

covered with charcoal. A pole, commonly of birch, is then held in the liquid matter, which causes considerable ebullition, owing to the evolution of gaseous matter; and this operation of *poling* is continued, adding occasionally fresh charcoal, so that the surface of the metal may be kept covered, until, by the assays which the refiner from time to time takes, he perceives the grain, which gradually becomes finer, is perfectly closed, so as to assume even a silky polished appearance in the assays when half cut through and broken, and it becomes of a light red colour. He then makes further trial of its malleability by taking out a small quantity in a ladle, and pouring it into an iron mould; and when *set*, beating it out while hot on the anvil with a sledge hammer. If it is soft, and does not crack at the edges, he directs the men to lade it out, which they do in iron ladles coated with clay, pouring it into pots or moulds of the size required by the manufacturer. The usual size of the cakes for common purposes is twelve inches wide by eighteen in length. The operation of refining requires great care; under-poling or over-poling being found injurious to the process.

Sometimes, when copper is difficult to refine, a few pounds of pig-lead are added to the charges of copper. The lead acts as a purifier, by assisting, on being oxidised itself, the oxidisation of the iron or any metal that may remain combined with the copper, and not, as may be supposed, by uniting with the copper, and thereby increasing its malleability. This is a mistaken notion: indeed, the smallest portion of lead combined with copper, renders the metal difficult to *pickle* or clean from oxide, when manufactured.

Copper for making brass is granulated, that its surface may be increased, so as to combine more readily with zinc or calamine. This is effected by pouring the metal from the ladles in which it is taken out of the furnace into a large ladle, pierced in the bottom with holes, and supported over a cistern of water. The water may be either hot or cold, according to the form

to be given to the metal. When warm, the copper assumes a round form, and is called *bean shot.* When a constant supply of cold water is kept up, the metal has a light ragged appearance, and is called *feathered shot.* The former is the state in which it is prepared for brass wire making. Another form into which copper is cast, chiefly for exports to the East Indies, is in pieces of the length of six inches, and weighing about eight ounces each: these are called Japan copper.

The houses for smelting and rolling the copper in Cornwall are chiefly in the neighbourhood of Hall, a generally dismal-looking tract on the eastern side of the river of that name. The perfection of the works, and the deleterious nature of the avocations connected therewith, long ago attracted attention to this place. "Nothing," says Dr. Maton, "can be more shocking than the appearance which the workmen in the smelting houses exhibit. Some of the poor wretches, who were lading the liquid metal from the furnaces to the moulds, looked more like walking corpses than living beings."

Not only do the workmen immediately engaged in the smelting suffer as is stated, but the noisome effect is perceived by the inhabitants of the districts where such operations are carried on. In the year 1821, the Great Hafod copper-works, in the neighbourhood of Swansea, and which were erected at an expense of about 150,000*l.*, were indicted for a nuisance, in consequence of the alleged destructive effects of the fumes which arose during the smelting of the ores. "When we learn," says Doctor Paris, "that the amount of wages paid by the proprietors of the works in this district exceeds 50,000*l.* per annum; that 12,000 persons, at least, derive their support from the smelting establishments; that a sum of not less than 200,000*l.* sterling is annually circulated in Glamorganshire and the adjoining county in consequence of their existence; that they pay to the collieries no less than from 100,000*l.* to 200,000*l.* per annum for coal; that 150 vessels are employed in the conveyance of ore; and, supposing each

upon an average to be manned by five seamen, that they give occupation to 750 mariners; a more serious calamity can scarcely be imagined than the stoppage of such works." — "We may, therefore, readily believe," adds the biographer of sir Humphry Davy, "that this distinguished chemist, who was applied to on the subject, entered most ardently into the consideration of some plan by which the fumes might be prevented, and the alleged nuisance abated." The method adopted by Messrs. Vivian and Co., the proprietors of the works, for the mitigation of the evil complained of, was the erection of shower-baths; and experiments, made by Messrs. Phillips and Faraday, proved that, by that means, all the fluoric and arsenious fumes of the smoke were entirely destroyed; and, further, that by a *certain* quantity of water, the smoke might be entirely freed from sulphurous acid gas. After a mature consideration of the great mechanical as well as chemical difficulties which the condensation or decomposition of the smoke on a large scale presented, Davy strongly recommended the continuance, and, if necessary, an extension, of the plan adopted by the proprietors. This plan appears analogous to — if not, indeed, identical with — one for which, in the above year, Mr. Dickson obtained a patent.

Contiguous to the Hafod works, the operations connected with rolling the metal are conducted on a large scale. The cakes of copper are here manufactured into sheets and sheathings for export and home consumption. It is packed into cases, which are lowered from the mills into vessels, and forwarded to the different markets. The *shruff*, that is, the edges (cut off on trimming the sheets), and the *pickle dust*, or oxide of copper, that is collected in the cisterns on cleaning them, are sent back to the refinery and remelted. For several years past, Government has maintained an establishment for the manufacture of copper into sheets and bolts at Portsmouth; the quantity used there being, in 1830, 641 tons; in 1831, 580 tons; and, in 1832, 644 tons.

Besides the reduction of that variety of ores from

which copper is extracted, there is another method which has been turned to considerable account in the production of this valuable metal; namely, by smelting the rust or oxide which is deposited upon bars or pieces of iron exposed to the action of springs strongly impregnated with metalliferous properties. When first the phenomenon here mentioned was observed, and the reality and importance of its effects ascertained beyond a doubt, the result was for a time characterised, by persons deficient in chemical knowledge, as an actual transmutation of the iron into copper; pieces of the former metal appearing to be decomposed in proportion as the oxide of the latter was produced. This opinion was the less surprising, when it is considered that, not only were many appearances, now familiarly explained by chemistry, but imperfectly accounted for, but because travellers especially were not always the persons most conversant with such doctrines as might be deemed authentic on these matters. In later times, however, not only have springs impregnated with copper been turned to direct advantage by the smelter, and their principles been illustrated by analysts; but Dr. Brewster mentions a case, from the *Annales de Chimie*, in which small buttons of pure copper, one of them weighing two ounces and a half, and perfectly malleable, were actually produced, *viâ humidâ*, inside a tub used in the preparation of sulphate of copper.

With reference to the alleged transmutation of iron into copper, at which travellers have been so much surprised, and the old chemists so much puzzled, especially by the effect of the waters of Newsol, in Hungary, mentioned by Agricola, bishop Watson remarks that, in the year 1673, our countryman Dr. Brown visited the famous copper mine at Herrn-Grundt, about seven English miles from Newsol; he informs us that he there saw two springs, called the Old and New Ziment, which turned iron into copper. The workmen showed him a curious cup, made of this transmuted iron; it was gilt with gold, had a rich piece of silver

ore fastened in the middle, and the following inscription engraved on the outside: —

> Eisen ware ich, kupser bin ich,
> Silver trag ich, gold bedeckt mich.
>
> Copper I am, but iron was of old,
> Silver I carry, covered am with gold.

It was even at that time, says Brown, contended by some, that there was no real transmutation of the iron into copper, but that the Ziment water, containing vitriol of copper, and meeting with the iron, deposited its copper; and, it seems, he would have acceded to this opinion, could he have told what became of the iron. "It is," says Dr. Watson, "taken up by the water, and remains suspended in it, in the place of the copper; so that the transmutation is nothing but a change of place; and as the copper is precipitated by the iron, so the iron might be precipitated by potash, or any other substance which has a greater affinity with the acid of vitriol than iron has."

The copper springs in the county of Wicklow, in Ireland, owed the discovery of their valuable quality to the following circumstance. About the middle of the eighteenth century, when the opening of the rich mines of Crone-Bawn had compensated the loss of the more ancient workings of Ballymurtagh, a workman happened to leave an iron shovel in one of the levels from the former mine, by which issued a copious stream strongly impregnated with copper: on taking out the implement some weeks after, it was found so completely incrusted, that it was at first thought to be converted into copper. This accident suggested the advantage of laying bars of iron in the streams, by means of which the copper in the water was precipitated upon the iron, which became corroded by the process, and fell to the bottom as a reddish mud, and which, on being taken out and dried, appeared a sort of dust of the same colour, in which state it was ready for smelting. About 500 tons of iron were laid at one time in

these pits: in about twelve months, the bars became dissolved; one ton of iron yielding a ton and a half, and sometimes nearly two tons of the metalliferous precipitate; and each ton of the latter producing sixteen hundredweight of pure copper. It is a knowledge of this affinity between the two metals that has furnished the miners with a very simple but almost infallible method of ascertaining whether an ore contains copper: they drop a little nitric acid upon the mass; and, after a while, dip a feather into the acid, and draw it over the polished blade of a knife; and if there be the smallest quantity of copper present, it will be precipitated on the steel.

CHAP. IX.

MANUFACTURED COPPER.

COPPERSMITH OR BRAZIER. — ANCIENT TARIFF OF WAGES. — DYNANDRIE. — HAMMERING AND SOLDERING. — COPPER PIPING. — MAKING A TEA-KETTLE. — DOUBLE BOTTOMS. — TINNING OF COPPER VESSELS. — DELETERIOUS SOLUTIONS OF THE METAL. — PLATES FOR ENGRAVING. — CALICO-PRINTING ROLLERS. — CYLINDERS. — SHEATHING FOR SHIPS. — SIR HUMPHRY DAVY'S EXPERIMENTS. — KING'S SHIPS ORDERED TO BE COPPERED ON THE NEW PLAN. — FAILURE OF THE GALVANIC PROTECTORS. — ALLOYS FOR SHEATHING SHIPS. — WHITE COPPER. — PACKFONG. — MATERIAL AND MANUFACTURE OF COCKS FOR DRAWING LIQUIDS.

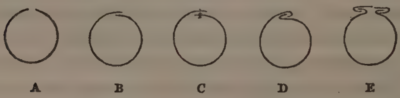
The business of the coppersmith is as extensive and diversified, as the purposes to which the metal is applied on a large scale are considerable. The appellation of brazier, although in strictness applied to an artificer in brass, as contradistinguished from one who works in copper, has long since sunk into a synonyme with the first-mentioned term; and it is likely, even in times and countries very remote from our own, both metals might be fashioned into domestic or other utensils by the same class of workmen. In a very curious tariff of the prices of about 400 commodities, promulgated in the reign of the emperor Diocletian, in the year 302, a translation of which document, with the sums reduced to English money, is appended to Colonel Leake's "Journal of a Tour in Asia Minor," &c. occurs incidentally an item to the effect, that the highest charges which it was then lawful for a brazier to make for his work were, in brass, *5s. 3d.*, and in copper, *3s. 10d.* per pound. This rate of remuneration, however, was fixed immediately after a year of dearth; and what proportion it bore to the price of provisions may be inferred from

the statement that a fat goose is priced at the sum of *6l. 2s.*, and a peck of bruised peas at *3l. 4s.* In the eleventh century, Dynant in Flanders was famous throughout Europe for the manufacture of pots, pans, and other articles of copper, which were long known in commerce under the name of dynandrie, from the place where they were made. And, previous to the period when Queen Elizabeth encouraged miners and brass-workers to settle in this country, we imported from Germany, through the ports in the Netherlands, not only swords, knives, saddlers' ironmongery, and even pins, but all our articles of brass and copper, called battery wares, from their having been wrought by the hammer. Although copper may be, and to a considerable extent is, cast in sand, like other metals, it is in the state of sheets that the largest consumption takes place, especially when we consider what is required by the shipbuilders. Copper, although somewhat difficult to turn at the lathe, or to bore, on account of its clogging the tools, is an exceedingly easy and pleasant metal to fashion by hammering, being at once soft and tenacious. Some articles, being first cast, are afterwards beaten out to the requisite degree of thinness, and to the form intended, advantage being taken of the malleability of the material, by repeatedly heating until red-hot, and then gradually cooling whatever piece of work may be wrought in this manner. Other things, such as kettles, pitchers, and small vessels in general, are soldered; the seams, after lighting in the manner just described, being found to stand the operation nearly as well as the other parts of the article, care being taken neither to heat nor hammer those parts more than necessary. The hard solder used by the brazier is composed of three parts of brass, and one part of zinc, and is thus prepared: — The brass is put into the crucible with a little borax: when melted, the zinc is added, and the mixture stirred well together, until the blue flame subside: it is then poured out into a shallow pan or ingot mould, so as to form a plate. It is afterwards granulated, by heating nearly red-hot,

and then beating it on an anvil or in a mortar. The larger grains are separated from the finer by means of a riddle.

In boilers, gasometers, stove-pipes, and other large articles, the pieces are attached by studs or rivets driven, at short distances apart, through holes punched in the metal, and spread out on one side by repeated strokes with a hammer, while a small anvil is held against the head of the rivet; a cement made of powdered quick-lime and bullock's blood is sometimes smeared in the seams of large vessels, which by this means are not only rendered very firm, but impervious to liquids. In some sorts of piping, the edges of the metal are made to overlap each other; or, being bent outwards, a strip of metal is tucked over both of them; after which the whole is hammered down, and a compact seam formed. The following sections of piping will show the method of making the different sorts of seams by the copper-smiths (*fig.* 27.); A, simple contact of the edges for

Fig. 27.

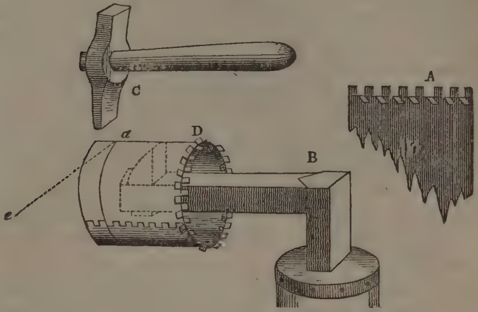


hard soldering; B, overlap for soft soldering; C, overlap with rivets; D, folded seam; E, patent strip overlap.

A copper tea-kettle presents a familiar but ingenious specimen of the coppersmith's art, both with reference to soldering and hammering: taken, indeed, in all its parts, it exhibits the result of almost every operation of his workshop. A piece of metal being cut from the sheet, of a size corresponding with the intended capacity of the kettle, it is brightened by filing over about an inch of the surface at each end. It is then cut with a pair of shears along one end at intervals of an inch, and every alternate portion of the edge bent back a little, as

represented at A (*fig.* 28.) It is next bent upon a large mandrel in the manner of a tube, the entire edge

Fig. 28.



being introduced between the cut portions of the other; these, when the parts are hammered close, lying alternately inside and out of the vessel. The seam is now to be brazed by the introduction of borax, burnt and triturated with water, and a sprinkling of the solder already mentioned; the part being held over a coke fire urged with bellows, until the solder melts. The vessel, when cooled, is hammered upon a steel head or stake, being lighted occasionally, until the seam is laid smooth, and the body, as to its cylindrical measurement, is correct. Two inches of the tube are next to be turned inward, to form the top of the kettle; this is done by placing it over a little anvil with a sloping face, attached to the stake B, and striking the vessel with the edge of a hammer, C, until it form an obtuse angle with the sides, as *a e*. This part being contracted, so as to form a suitable cavity for the lid, the lower end is, by a similar operation, turned inward a little, all round, and then cut with the shears, as D, the bottom being inserted, and the alternate projecting bits of metal hammered upon it, after which it is soldered in the same manner as the side. The article is now pickled in

diluted sulphuric acid, and planished to brightness, the marks of the hammer being rendered imperceptible by the intervention of a piece of old moreen, or other woollen stuff, between the copper and the stake. The lid of the kettle is dished by stamping it in a die; the handle is cast, and the spout, after being soldered up, and rounded a little on a mandrel, is finally shaped upon lead with which it had been filled, and afterwards soldered or riveted into its place. Copper tea urns and saucepans are formed by soldering and hammering in a similar manner, the former being in general finished with a beautiful colour, produced by the application of sulphate of copper or Roman vitriol, previous to the planishing or burnishing.

Every person conversant with the most ordinary culinary operations, has noticed how often liquids, especially milk, is spoiled, by what is called "burning to the saucepan." To prevent this evil effectually, Count Rumford recommends double bottoms to all boilers and saucepans used in cooking. "The heat," he observes, "is so much obstructed in its passage through the thin sheet of air which, notwithstanding all the care which may be taken to bring the two bottoms into contact, will still remain between them, that the second has time to give its heat as fast as it receives it to the fluid in the boiler; and consequently, it never acquires a degree of heat sufficient for burning any thing that may be upon it." He suggests the expediency of doubling small copper saucepans and kettles throughout; and as this may be done with a very thin inner sheet of metal, the cost would not be much, even if the lining were of silver. When the two sheets of metal forming the double bottom, are made to touch each other throughout by hammering, they may be fastened together by a few small rivets, and afterwards be tinned, by which latter operation the edge of the false bottom may be soldered to the sides, and thus the water, or other liquids put into the boiler, be prevented from getting between the two bottoms.

Copper vessels, when not very large, and particularly if intended to hold liquids, or dress food for human sustenance, are tinned inside. This is easily done, by brightening the metal, either by means of scraping, or rubbing it with sand-paper; then moistening it with a solution of sal-ammoniac, after which a quantity of grain tin is thrown in, and the vessel moved about over a moderate fire, until the mixture is melted, when the inside may be rubbed with a handful of hurds, to distribute the tin more uniformly, that portion which does not adhere being poured out. In 1770, a Scotch brazier obtained a patent for a method by which the tinning was to last ten times longer than by the common process. His plan was, to rough or "freeze" the copper by hammering on a stake having the surface cut like a file, then upon this grain to tin it as above described, and afterwards to give it a coating of an alloy composed of one pound of grain tin, and half a pound of zinc or spelter; the article then to be planished hard and smooth inside, and lastly, polished with whiting. Various attempts have been made, and some patents obtained, to supersede the tinning of iron and copper vessels of a certain class, as used for culinary purposes, but with no beneficial results. Amongst other alloys the precious metals have been proposed, and more particularly a process similar to enamelling. Although injurious and even fatal effects have undoubtedly sometimes resulted from the use of culinary vessels of naked or badly tinned copper, yet instances of this sort are very uncommon; and the late professor Proust, in a dissertation on tinning, has shown that the danger is by no means so great or so general as to excite much anxiety, even when vinegar and other acidulous liquids are boiled. Indeed, the daily use of brass pans and copper saucepans, for preparing pickles and conserves, by a large proportion of the population of this country, and this without attendant ill consequences, shows that, if such matters are not suffered to remain to cool in the vessels, no danger need be apprehended. Unctuous solutions

are most liable to become impregnated with poisonous verdigris if left long in untinned brass or copper vessels. Sir Humphrey Davy asserts that *weak* solutions of common salt, such as are daily made by adding a little salt to boiling vegetables and other eatables in our kitchens, act powerfully on copper vessels, although *strong* ones do not affect them.

Sheet copper of the finest and purest quality is in extensive demand with the engravers; and this, notwithstanding the large use of steel plates of late years among this class of artists. For this purpose, the metal, rolled to different thicknesses, so as to suit the sizes of plates, is sold by the maker to the London dealer in copper plates, who cuts it according to his convenience, planishes it, and gets up the surface in that beautiful dead smooth style admired by the engraver. Cylinders of copper, either cast or drawn upon iron rollers, are used in calico-printing; they are turned very true and smooth at a slide lathe, receiving at the same time any circular lines intended to yield stripes of colour, after which the various figures are either cut upon the surface, or impressed by means of engraved steel punches. Those elegant styles of embossing calicoes and other fabrics called watering are produced from figured cylinders of this description, but generally made of a copper alloy similar to gun metal; and, instead of being charged with colour, they are kept hot by means of a heater inside, and are made to revolve, with a considerable degree of pressure, against cylinders composed of a great number of thicknesses of soft paper pasted upon an iron axis. Copper is frequently drawn into tubes for the barrels of pumps, of which the rest of the body is lead or cast iron: in some instances also the working cylinders of small, and the air-pumps of large steam-engines are lined with copper, the insides being worked true and smooth, by means of a wooden or metal head, fixed on a revolving shaft, and armed with steel cutters, as in the boring of cylinders.

It has already been observed, that sheet copper is

largely used for sheathing, or covering externally the bottoms of ships, in order to defend them from the depredations of marine animals, as well as to preserve them generally from decay. The sheets applied by shipbuilders for the above purposes are of various sizes, and rolled to different thicknesses; the sheathing of a vessel being laid on thicker where most exposed, and vice versâ: twenty-two ounces of metal to the square foot, is reckoned a very stout sheathing. The plates are fastened to the keel and planks by means of copper nails, which, as well as the butt bolts, keel staples, clench rings, deck nails, &c. ought to be cast, the metal being considered strongest in that state. Notwithstanding, however, the comparative anti-corrosive qualities of copper, and the great advantages of applying it to the covering of ships' bottoms, the decay of the metal, from the peculiar effects of the salt water, is not only rapid, but vessels are often found, especially after long voyages, to return clogged with such prodigious marine accretions, organised and otherwise, as materially to affect their sailing: and hence the least inconvenience is, that they require to be frequently dry-docked, that the barnacles and other adhesions may be knocked off; an operation which is not repeated without loss of time and injury to the sheathing.

The use of metallic sheathing for the protection of ships' bottoms against the ravages of marine worms is of ancient date. The galley supposed to have belonged to the emperor Trajan, was sheathed with sheets of lead, which were fastened with copper nails. The same metal was also used in the earlier periods of our naval history. In the year 1670, an act of parliament was passed, granting unto sir Philip Howard and Francis Watson, esq. the sole use of the manufacture of milled lead for sheathing ships; and, in the year 1691, twenty ships had been sheathed with lead manufactured by them, and which was fastened with copper nails. The discovery of galvanism, and the singular application of

one branch of it, as about to be mentioned, has made it worthy of remark, that the circumstances which led to the disuse of lead, were, the rapid corrosion of the rother irons (from the formation of a voltaic circle), and the accumulation of sea-weed. In the year 1761, copper plates were first used as sheathing on the Alarm frigate, of 32 guns: two years afterwards these were removed, when the iron was found to be much corroded. A second vessel underwent the operation of coppering in 1765, a third in 1770, four in 1776, nine in 1777; and in the course of the three following years the whole British navy was coppered. Some notion of the quantity of metal used for this purpose may be had from the fact that a single ship, the Neptune of 120 guns, launched at Portsmouth in 1832, was cased with 4738 sheets of copper, weighing altogether 17 tons 19 cwt.

The expense attending the sheathing of ships with copper, in consequence of its corrosion and decay by salt water, has always been felt as a serious objection to its use, and various suggestions have from time to time occurred, and numerous experiments been made, in the hope of obviating the evil. In order, if possible, to obtain an efficient remedy, the naval department of the government requested, in the latter part of the year 1823, the advice of the president and council of the Royal Society, as to the best mode of manufacturing copper sheets, or of preserving them, while in use, against the corrosive effects of oxidation. Sir H. Davy charged himself with this enquiry, the results of which he communicated to the Royal Society, in three elaborate memoirs. The first was read in January, and the second in June, 1824; the third and last in June 1825.

Doctor Paris, in his interesting "Life of sir Humphry Davy," and from which work the foregoing particulars are taken, nearly verbatim, enters at length into the chemical as well as the practical details and results of this investigation, undoubtedly one of the most interesting in which modern scientific research has been engaged. "A very general belief prevailed," says Dr.

Paris, "that sea water had little or no action on *pure* copper, and that the rapid decay of that metal on certain ships was owing to its impurity. On submitting, however, various specimens of copper to the action of sea water, sir H. Davy came to a conclusion in direct opposition to such an opinion. In two instances, the copper (from the Batavier and the Plymouth yacht) which had remained perfect for twenty-seven years, was found to be alloyed. In the former one, there was an alloy of one three hundredth part of zinc; and, in the latter, the same proportion of tin. On the other hand, in the case of the sheathing on the Tartar's bottom, which was nearly destroyed in four years, upon being submitted to chemical examination by Mr. Phillips, it was found to be very pure copper." Mr. Knowles, the author of an "Enquiry into the Means which have been taken to preserve the British Navy," informed Dr. Paris, in a conversation on the subject, that the attempts to purify the metal, since the government has manufactured its own copper sheathing, has been the cause of its more rapid decay. It appears, indeed, as the latter remarks, "that the relative durability of the metallic sheets must also be influenced by circumstances wholly independent of their quality, some of which are very probably, even in our present advanced state of chemical knowledge, not thoroughly understood."

After a series of experiments founded upon and strikingly confirmative of his electrò-chemical theory, sir Humphry communicated the important fact of his having discovered a remedy for the evil of which they had complained; and that the corrosion of the copper sheathing of his majesty's ships might be prevented by rendering the copper electro-positive, by means of the contact of tin, zinc, lead, iron, or any other easily oxidable metal; and that he was prepared to carry his plan into effect. In his second memoir on this subject, addressed to the Royal Society, sir H. Davy states that, "when the metallic protector was from $\frac{1}{20}$ to $\frac{1}{110}$ parts of its surface, there was no corrosion or decay of the cop-

per; with smaller quantities, such as from $\frac{1}{200}$ to $\frac{1}{400}$ the copper underwent a loss of weight, which was greater in proportion as the protector was smaller. Fortunately, in the course of these experiments, it was proved that cast iron, the substance which is cheapest and most easily procured, is likewise most fitted for the protection of copper. It lasts longer than malleable iron or zinc; and the plumbaginous substance which is left by the action of sea water upon it, retains the original form of the iron, and does not impede the electrical action of the remaining metal."

In the month of May, 1824, the lords of the admiralty, convinced of the practicability of thus defending the copper by voltaic action, issued directions for the sheathing of all his majesty's ships which might be taken into dock, upon the plan proposed by sir Humphry Davy. "The protectors," says Dr. Paris, "were bars of iron six inches wide at their base, three inches in thickness at their centre, and, in outward form, the segment of an extended circle. They were usually placed on each side of the ship in a horizontal position, viz. in midships, about three feet under water; on the keel, in a line with these; and the remainder in the fore and after parts of the ship (about three feet under the line of fluition), as far forward and abaft as the curvatures of their respective bodies would allow of their lying flat upon the surface of the copper. To bring about the best possible contact of all the copper sheets, their edges, which lap over each other, where the nails are driven through them into the ships, were rubbed bright, first with sand-paper, and finally with glass-paper. Shortly after the ships thus protected were sent to sea, it was evident to all on board, from their dull sailing, that the bottoms were become very foul; and on being examined in dry docks, it was found that the copper was completely covered with seaweed, shellfish of various kinds, and myriads of small marine insects. Upon their removal, however, it was found, on weighing the sheets, that the copper had suffered little or no loss; thus

proving, that although its practical application had failed from unforeseen circumstances, the principle of protection was true, and had fully justified the expectation of its success." The ultimate issue of this truly ingenious and philosophical application is thus recorded by Dr. Paris:—" The disadvantages which arise from the foulness of ships' bottoms, particularly when on foreign stations, where there are no dry docks to receive them, are so serious, that the government was obliged, in July 1825, to order the discontinuance of the protectors on sea-going ships; but directed that they should still be used upon all those that were laid up in our ports. When, however, an examination of the latter took place, they were found to be much more foul than those which had been in motion at sea: shell-fish of various kinds had adhered to them so closely, that it was even necessary to use percussion to remove them, which not only indented the copper, but in many instances actually fractured it. Under all these discouraging circumstances, the unwelcome conviction was forced upon the agents of government, that the plan was incapable of successful application, and it was accordingly altogether abandoned in September 1828." It may be added that, although vessels are still coppered as before, yet, so lately as within the year 1833, a ship intended for service was ordered by the lords of the admiralty to be sheathed with lead instead of copper.

The importance of the object to which the foregoing investigation was directed, has led to the trial of various alloys designed for the same purpose: some of these have been already noticed. In 1831, Mr. Uzielli obtained a patent for a process communicated to him by some foreigner residing abroad, the object of which was to give ductility and malleability to an alloy composed of copper and tin solely, or which should be so far free from admixture of zinc or lead, as to be harder and less liable to oxidation than pure copper or common sheet brass; and which alloy, although brittle when cast, is by

the process described made into malleable sheets, which being so little liable to oxidation, are more applicable than copper to the sheathing of ships, covering of buildings, making spouts and gutters, and other purposes. The proportions which the patentee recommends as best adapted for the object proposed are, 100 parts of copper with five to seven of tin. A less quantity of tin than about five per cent. makes an alloy which is too liable to oxidation, and is little preferable to pure copper; and a greater quantity than about nine per cent. makes an alloy so hard and brittle, and requiring so much care and labour to reduce it into malleable sheets, as to become too expensive an article for sale.

Mr. Uzielli thus manufactures his alloy into sheets:—Having melted the copper in a reverberatory or other furnace adapted to the purpose, or in iron crucibles, the tin is added, and then the metals are to be well incorporated and mixed together by stirring while in a state of fusion. The melted mixture or alloy is then to be well heated, and a sufficient quantity is to be poured into moulds formed between two strong tables of smooth granite or other suitable substance, so as to obtain a flat plate of from $\frac{3}{8}$ to $\frac{3}{4}$ of an inch thick, according to the ultimate thickness of the sheets required. These plates are placed in an annealing or other furnace, where they are very gradually heated for two or three hours, until they are raised to a dull red heat, when the alloy contains from five to seven per cent. of tin: but if it contain more tin, the heat must be lower, and applied more gradually; and if less tin, the reverse. The plates are then allowed to cool gradually, which will take about an hour; and when perfectly cold, they are passed between rollers, set so as to effect but a very slight reduction of the thickness of the plates—about half an inch in two feet length. The plates, being again annealed and carefully cooled as before, are repeatedly rolled, until the texture of the alloy is changed, as may be known by the fracture being found close and fine-grained, instead of crystallised and with facets, as it

appeared when first cast. With the proportions before recommended, the close and fine grained texture generally takes place after twelve or fifteen operations of annealing and cold rolling. After the texture of the alloy becomes thus changed, it may be heated more rapidly and to a higher temperature, and when cold, rolled, so as to lengthen plates, which when cast were of two feet length, six or seven inches after each annealing. The plates, or sheets, as they may now be called, may then be bent up and rolled double, in the usual manner of rolling brass sheets, but continuing always the precaution of rolling them in the same direction.

Mr. Muntz of Birmingham has a patent for making bolts and other ships' fastenings of an alloy of zinc and copper, in such proportions and of such qualities, as while it enables the manufacturer to roll and work it at a red heat, and consequently cheaper, renders the articles made thereof less liable to oxidation, and of course more durable than those made in the ordinary manner. The patentee thus describes the process of manufacture: —"I take that quality of copper known in the trade by the appellation of 'best selected copper,' and that quality of zinc known in England as 'foreign zinc,' and melt them together in the usual manner in any proportions between fifty per cent. of copper to fifty per cent. of zinc, and sixty-three per cent. of copper to thirty-seven per cent. of zinc, both of which extremes, and all intermediate proportions, will roll and work at a red heat: but as too large a proportion of copper increases the difficulty of working the metal, and too large a proportion of zinc renders the metal too hard when cold, I prefer the alloy to consist of about sixty per cent. of copper to forty per cent. of zinc. This compound I cast into ingots of any convenient weight, and then heat them to a red heat, and roll or work them while at that heat into bolts and other like ships' fastenings in the same manner as copper is rolled or worked, but only taking care not to overheat the metal so as to produce fusion,

and not to put it through the rollers, or work it after the heat has left it too much, say, when the red heat goes off." The same party has also a patent for manufacturing sheathing for ships of the same materials and by a similar process.

Copper, considerably alloyed with tin as in one of the foregoing compositions, has its original colour very much altered, though it is very far from being white, or the colour of tin, to which however it may be brought. Compounds resembling the "German silver," or by whatever name similar metals may be called, which has obtained considerable vogue within the last few years in the manufacture of various articles very much resembling silver, have been long known, as have also various imitations of gold. It will also readily be believed, that wares ostensibly of the precious metals, but composed wholly or in part of the factitious material, would in some instances be foisted upon the ignorant or the unwary, as indeed they still are. In the reign of William III. some acts were passed, making it felony to blanch copper in imitation of silver, or mix it with silver for sale; and the same of metals heavier than silver, made to look, feel, or wear like gold, but which were worse than standard. The component ingredients of these imitations of silver differ, according to modes adopted by different artisans, to suit their respective purposes.

According to a paper published some years ago in Schweigger's journal, white copper, strongly resembling silver, and exceedingly malleable, had long been manufactured into spurs and similar articles at Suhl, in the duchy of Saxe Hildburghausen: it was said by Keferstein to consist of the following component parts:—

Copper - - -	88·000
Nickel - - -	8·753
Sulphur, with a little antimony -	0·750
Silex, clay, and iron - -	1·750

White copper, as we have already stated, is well known

and highly esteemed in China, from whence it is smuggled into various parts of the East Indies, where, under the denomination of packfong, it has been sometimes mistakenly identified with tutenague, from which, however, it wholly differs. Dr. Fyfe, who analysed the Chinese white copper, describes a basin of it as approaching to the colour of silver, and so very sonorous that, on being struck with the fingers, the sound might be heard at the distance of a mile. It was malleable at a natural temperature, and at a red heat; but when heated to whiteness, it became quite brittle. It was found to consist of about one half copper; the other half consisting of zinc and nickel in nearly equal proportions, with a very small quantity of iron. It cost in China about one fourth of its weight in silver.

As the manufacturing of the ordinary sorts of liquor taps is generally the work of the brazier or the coppersmith, the method of making them may be here introduced. Although sometimes cast of fine brass, and got up in a superior style, the bulk of them is composed of inferior brass, or rather of copper, so saturated with lead, that on exposure to but an inconsiderable degree of heat, the latter ingredient readily oozes through the pores of the mass. Crude lead does not amalgamate with copper in the composition of cock metal; it is therefore arsenated, or "killed," as the workmen term it, as in the method of preparing it for shot already mentioned. Cocks are moulded, previously to casting them, in boxes of sand; the plug and the barrel from separate models. The latter, instead of having a longitudinal perforation, with a hollow space across it, for the reception of the plug, as in the finished article, has little knobs or projections, which make impressions in the sand suitable to corresponding pegs on the core, which is placed in the sand, after the removal of the model, where it remains when the metal is poured in. This core, which is the exact counterpart of the inside of the cock when cast, is formed of clay in the leaden moulds,

(*figs.* 29, 30.) which are made to correspond by means of the four ears on one side, and a like number of

Fig. 29.

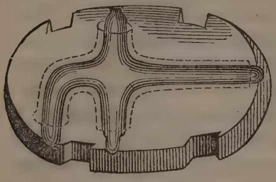
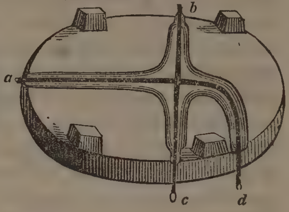


Fig. 30.



cavities on the other. *a, b, c, d,* represent two pieces of iron wire, sometimes placed in the mould to strengthen the clay core. The barrel, as it is sometimes called, or that perforated part in which the plug works, is made exactly smooth and slightly tapering, by means of a quadrangular steel rinder of the proper form and size: to make this tool cut smoothly, four spells of wood are placed against the sides: these, while by filling the cylinder they cause the rinder to revolve steadily, do not interfere with the cutting edges, except to prevent them from biting too keenly and jarringly. When this perforation is finished, the plug is first carefully turned so as to fit it, and then the parts are ground together with a little fine soft sand and oil. The outside is got up by filing, turning, and burnishing. As the perfection of the cock as to workmanship as well as for use, depends mainly upon the close fitting of the plug, combined with the ease with which it may be turned, various contrivances have been resorted to for this purpose. In the commonest kinds of cocks, the plug is simply rivetted at the lower end; in others, a screw is used; and in some, a coiled spring is added, at either end of the plug, by the action of which the parts are kept in contact, and at the same time smoothness of working is secured. Besides the ordinary T plug, there are several made to turn only by the application of a loose key; and others,

with which leather or other descriptions of packing are used. In 1806, Mr. Cawood, a founder at Leeds, obtained a patent for casting cocks of soft iron: these are afterwards fitted with bushes and other parts of brass or bell metal, and attached by hard or soft solder. Cocks manufactured by the above method are not liable, as is often the case with those cast of the usual compound metal, either to become cloggy, or to expand and contract considerably with each change of temperature. They are moreover readily renewed in the parts exposed to wear. "Common cocks," says the patentee, "when out of repair, are in general sold as old metal; for when they are ground two or three times, the hole in the piston is so low in the cylinder, that it will not admit a sufficient quantity of fluid equal to the bore of the cock; but in these plated cocks, when the piston is worn too low, which will rarely be the case, owing to the superior quantity and hardness of the metal which comes in contact when in use, the piston or cylinder can be plated at a trifling expense, and the cocks rendered as good as new: this, in large cocks, for which this invention is more especially adapted, will be a great saving."

CHAP. X.

BRASS.

BRASS A COMPOUND METAL. — ITS QUALITIES AND VARIETIES. — BRONZE CUTTING INSTRUMENTS OF ANTIQUITY. — BRITISH OR CELTIC IMPLEMENTS OF BRONZE. — HARDNESS OF ALLOYS OF COPPER AND TIN. — CELTS. — BRAZEN MONUMENTS AND SEPULCHRAL BRASSES. — ORIGIN OF BRASS WORKS IN ENGLAND. — HOW INTRODUCED INTO BIRMINGHAM. — PROCESS OF MAKING BRASS. — CASTING BRASS PLATES AT STOLBERG. — MANUFACTURE BY CEMENTATION. — CHEADLE PRODUCES FINE BRASS. — TOMBAC, OR YELLOW METAL.

Brass is a compound metal, of a yellow colour, and the base of which is copper, the specific ingredient united with it being lapis calaminaris, an ore of zinc or spelter: the latter usually denotes a semi-metal brought in considerable quantities from the East Indies; the former, a peculiar mineral product found under various modifications, but abounding in our own country. Next to iron, brass is of the greatest use in the modern arts and manufactures. As it is differently compounded or alloyed, it is more or less adapted for that amazing variety of purposes to which it is so extensively and profitably applied. When in its purest state from the foundery, it is so soft and malleable as easily to admit of being spread out into sheets under the rollers; and it may be beaten out into tinsel with the utmost facility. Not only between the rollers, or under the hammer, is this valuable property of good brass exhibited, but especially in passing through the whortle, whether for the formation of tubes, or in the drawing of wire: by these means, indeed, its ductility is turned to wonderful account: it is even more capable of extension by the latter process than copper. Mr. Smeaton found that twelve inches in length of cast brass, at 32°, expanded

by 180° of heat, ·0225 parts: brass wire, under the same circumstances, expanded ·0232. The expansion of hammered copper is only ·0204, but that of zinc is ·0353, so that in this respect brass appears to hold a middle place between the component metals. Brass admits of being stamped or embossed with a degree of ease which renders it incomparable in cheapness and beauty for innumerable useful and ornamental purposes. It is, when of a harder composition, the most convenient metal known for the making of large and fine, and especially of tubular, screws, as, notwithstanding its compactness of texture, it is wrought at the lathe with an ease greatly superior to that of any other metal, tin excepted. Hence, for horological works, and mathematical instruments generally, fine brass combines the qualities of tractability in cutting and durability in wear, to a surprising degree: at the same time that it yields most favourably to the tools of the turner, it is often so hard as to resist almost any pressure to which iron would not yield, and so compact as to receive, when required, a very high polish, which, added to its colour, justifies its pre-eminent place among the common metals. Alloyed with tin, brass becomes a sort of bell-metal, extremely hard, frangible, and difficult to be cut; or it may, by admixture with lead, be rendered soft, as in the compound usually termed "cock-metal," and which is used in the manufacture of the cheapest descriptions of taps. The brass of commerce varies greatly in species and value; but it is still further diversified in composition as it passes through the furnace of the local caster, so that the colour and quality are often deteriorated below even the price itself.

In no respect, however, does modern art require to have brass made of such hardness or composition as to serve any purposes of cutting, as we have seen was the case with some ancient nations: nor was this use of the alloys of copper confined to the larger or coarser tools; for, among the most curious discoveries of metallic

articles in the excavations of Herculaneum may be mentioned a set of chirurgical instruments of bronze.

A variety of conjectures have been put forward as to the methods by which the brazen implements of antiquity were rendered sufficiently hard for the purposes to which they were undoubtedly applied. Count Caylus asserts that the ancients had two methods of hardening copper; namely, by cementation and by admixture with iron. The first method he has not explained; nor does there seem to be any known process of hardening copper, without addition, except by hammering it, which, it is well understood, cannot produce the required hardness. As to alloying the copper with iron, the notion not only appears absurd, but unsupported by evidence. Dr. Lort, in a paper on Celts, printed in the Archæologia, holds the opinion formerly current. "It appears," says he, "that the ancients had an art of tempering and hardening brass to a greater degree than is done at present; or, perhaps, than is necessary to be done." Of the same opinion was that experienced enquirer Dr. Priestley, who asserts that "the ancients had a method with which we are not well acquainted, of giving to copper a considerable degree of hardness, so that a sword might be made of it with a pretty good edge." Pauw goes further when he tells us that the aboriginal Americans were in possession of the secret of giving a temper to copper equal to steel.

In the Philosophical Transactions of 1796, there are a series of observations, by Dr. Pearson, on some ancient metallic arms and utensils, which had been found in the river Witham, between Kirkstead and Lincoln. Of these articles, a lituus, or crooked musical tube, a spear head, a saucepan, and three celts, were of brass; or, rather, of copper alloyed with tin. These celts, in common with many others that have been found, are supposed to have been cast; the more ancient ones of flint having been used as the models. "They were, probably," says Dr. Pearson, "instruments used by the Britons, Gauls, or Celtæ. The learned do not agree

whether the celts were of Roman workmanship or not, nor to what particular uses they were applied. Accordingly, some persons have supposed that they were the offensive weapons of our ancestors; and others have supposed that they were both the offensive military weapons and civil instruments; but the most probable opinion is, that they were merely domestic tools. Many of the celts are cast after the model of stone implements which are confessedly ancient British or Celtic chopping instruments, and tools for making holes. Great quantities of them have been at different times discovered in England, as well as in Ireland, and some few in France. Sometimes they have been found in heaps, as if the owner had, and probably did, throw them away by basketfuls, as things of little value. It has been very ingeniously conjectured, that when the Romans came to Britain, they found the inhabitants, especially to the northward, very nearly in the same state as that in which the discoverers found the natives of the South Sea islands. The Britons parted with their valuable articles of food, rarities, and commerce, for metal tools made in imitation of their stone ones; but, in time, finding themselves cheated by the Romans, who made these tools of bad metal, of the shape of the ancient British stone axe, as the inhabitants of Otaheite were by the use of base metals, they relinquished these tools when they became acquainted with those made of better metal, and according to the Roman patterns. Hence we see a reason for such great quantities of celts being found among the Celtic nations, and not among the Romans, excepting now and then a specimen, which may be considered as the tool or spoil of barbarian auxiliaries." The writer then goes into a lengthened detail relative to experiments analytical and synthetical, from which he concludes that these articles were of copper alloyed with a small portion of tin.

Continuing his disquisition, Dr. Pearson observes that copper, alloyed with a somewhat larger proportion of tin than in gun metal in general, *i.e.* to twelve parts of

the former one of the latter, affords a material sufficiently hard and strong for chopping tools, for many useful purposes. Of the proportions of about nine parts of copper, and one of tin, there is very little doubt the ancient nations, who were acquainted with this alloy, generally made their axes, hatchets, spades, chisels, hammers, &c. These metals, united in the above proportions, afford the best substitute known for the instruments just mentioned, and now commonly made of steel or iron. "Accordingly, before the art of manufacturing malleable iron from cast iron was known at all, or, at least, practised extensively, that is, till within these last 400 or 500 years, the alloys of copper by tin must have been very generally employed. Copper, alloyed with a larger proportion of tin than is generally contained in celt metal; that is, with one sixth or one seventh of its weight of tin, is fitter for cutting instruments, and piercing, boring, and drilling tools, than celt metal; because it is harder, takes a finer edge, and yet is sufficiently strong on most occasions; nor do we possess, at this day, any metal that I know, which is so fit for knives, swords, daggers, spears, drills, &c. as this alloy, except iron and steel. The spear head contained tin in the very proportions here mentioned; and if the metals had been pure, it would, perhaps, not have been possible to have made this instrument of any other metals which were so proper, and at so small an expense. The saucepan was also made of alloy of copper with tin, in the proportions last mentioned; but, as this utensil is sufficiently hard with less or without any tin, there seemed to be no use for the addition of it. We may conjecture, indeed, that, as the saucepan was made of cast metal, the tin was added for the purpose of rendering the copper more fusible, and thus, also, for the more easily casting forms of it. Perhaps, also, the tin was added to make the copper less readily oxidable.

Of all metallic combinations, that of copper with tin, as Aristotle was aware, and as is well known to the

makers of bell-metal, that of copper with tin produces an alloy of the greatest density. Copper, alloyed with tin, in a somewhat larger proportion of the latter than is usual in the composition of gun-metal, affords a material sufficiently hard and strong for ordinary chopping tools, and other instruments. Of the proportions, therefore, of about nine parts of copper and one part of tin, there seems to be but little doubt that all ancient nations, acquainted with these metals, generally made their axes, hatchets, spades, chisels, anvils, hammers, &c.; as these metals, united in these proportions, would form the best substitutes for the like sort of articles which are now commonly made of steel or iron. Of such composition, as appears from the analysis of various brazen articles dug up at different periods in this island, may we suppose the ancient implements, both domestic and warlike, to have been, before the art of manufacturing malleable iron was known, or at least much practised. The celebrated antiquary, Ralph Herne, gives it as his opinion, that many of the brass wedge-like celts found in various times and places were Roman chisels, with which that people used to shape the stones used in building their camps. This, he asserts, is not conjecture only, as appears from the columna Trajana, where the soldiers are represented polishing the stones for the Roman tents in the Dacian wars, with such sorts of chisels made of brass, which they beat and worked into the stone and other materials with mallets of the same metal.

Although there can be no doubt that, by the terms in ancient authors, usually rendered orass by modern translators, copper, or some of its alloys with tin, must generally be meant in the original, it must by no means be supposed that the metal now under consideration is of recent discovery. Bishop Watson, indeed, was of opinion that it is identical with the orichalcum of antiquity. Aristotle mentions a kind of brass; and Pliny is supposed to allude distinctly to a compound of copper and zinc; while the explicit descriptions of other writers, and the preservation of various articles, prove

that the world has long been acquainted with this valuable product of our mines. The ancient Britons, there can be no doubt, long trafficked with the Romans for copper and brass, without supposing that their own island might be found to yield both in abundance. Whether the brazen celts, which have been found in such numbers in England and Ireland, were purchased of foreigners, or cast by the islanders themselves, from the flint models which they so much resemble, antiquaries are not agreed; it is, however, no violent presumption to suppose that the natives of Britain, so well acquainted with metallurgic operations in Cornwall, would not be slow to mix their own tin with the imported copper, and, finding the hardness of the compound, to cast it into those simple shapes in which we find their reliquæ, and for which clay moulds would be so easily prepared. Of the composition of brass, however, it is not likely they knew any thing at all; nor that, of the little they might procure by barter, in the condition of ornaments rather than utensils, is it to be supposed they would seek to alter the form by casting.

Previous to the establishment of Christianity in the Roman empire, the architects among that people are said to have had recourse to cast works of brass in the decoration of their public buildings; the vaultings of many of the temples in Rome having been relieved in their lacunaria by pateræ and other ornaments of brass or silver. At the restoration of the arts in the fifteenth century, and, indeed, before, most of these articles were removed for the sake of the metal, by the order of different popes, who had the most ingenious artists employed for the adornment of the many churches then erected under their auspices. Brazen monuments subsequently became exceedingly common throughout Christendom. Previous to the Reformation, large quantities of sepulchral brasses were imported into this country from the Netherlands. Few of the walls ro the floors of our more ancient churches failed to present some quaint portraiture — sometimes a whole

family — rudely but spiritedly delineated, some fanciful cross or crosier, or some flowing label inscribed with angular letters, and carefully embedded in stone. Some of our cathedrals were in this way ornamented with a profusion of brass garniture, to an extent which would scarcely be conceived by those who have paid no attention to the subject. The zeal which afterwards displayed itself in the destruction of popish memorials, found a ready excuse for the indulgence of cupidity in stripping away these brazen treasures, in the fact that they were symbols or sentiments of the denounced religion. "The cursed lust for *gold*" of the Roman poet was witnessed in respect of *brass* in another age and nation; rapacious hands in this Christian country, and under the colour of a holy cause, tearing from the gravestones hundreds of sculptured brasses, will hardly be supposed to have discriminated very precisely between those which bore the offensive "*Orate pro anima,*" and others of a more harmless but massive character. Many of these early plates, however, have been preserved; and many others have been added in subsequent years. As belonging to a superior class of workmanship, the brass railing around the monument of Henry VII., in Westminster Abbey, presents a splendid specimen of the brazier's art, as displayed at a time when the knowledge of the methods of working in brass was in general but little cultivated in this country.

At whatever period the knowledge of the composition of brass, or the arts of working it, might first reach this country, we owe, as Dr. (after bishop) Watson justly observes, not only our flourishing copper trade, but our extensive brass manufactures, to the wise policy of queen Elizabeth, in granting great privileges to Daniel Houghsetter, Christopher Schutz, and other Germans, whom she had invited into England in order to instruct her subjects in the art of metallurgy. Anderson, in reference to this matter, states that, in 1565, the queen, after reciting that she had theretofore granted

licences to certain Dutch or Germans to dig for alum and copperas, as well as for gold, silver, copper, and quicksilver in several counties, granted two exclusive patents to Humphreys and Shute (apparently the same individuals meant by Dr. Watson, and who had brought into England upwards of twenty foreign workmen), to dig and search for those metals, and also for tin and lead, and to refine the same in England, and within the English pale in Ireland. This is the origin of what was known so well afterwards as the charter for the mines royal. She, also, in the same year, granted them "the sole use of the calamy stone, for composition of a mixed metal called latten, and all sorts of battery works, cast works, and wire." Three years afterwards, she incorporated sir Nicholas Bacon, lord keeper of the great seal, Thomas duke of Norfolk, and others, jointly with the said Humphreys and Shute, by the name and designation of the governors, assistants, and society of the mineral and battery works. The brass works, at Baptist Mills, about a mile north-east of the city of Bristol, was the first manufactory of that metal established in this country; a large home and export trade is still carried on at that place, as well as at Mangotsfield, in the same neighbourhood.

The charter of incorporation above adverted to, was made a pretence for a copper bubble, in the famous year of speculative insanity, 1720. Soon afterwards William Wood, one of the most noted projectors of his day, published a quarto pamphlet, entitled The State of the copper and brass Manufactures in Great Britain, in which publication it is stated, that about 30,000 people were at that time supposed to subsist by those manufactures. He also remarks, that those metals were refined by pit-coal alone. "We have," says he, "plenty of lapis calaminaris for making brass. Copper ore is found in many counties of England, Wales, and Scotland: and this nation could supply itself with copper and brass of its own produce, sufficient for all occasions, if such duties were laid on foreign copper

and brass as would discourage their importation, and at the same time encourage the sale of our own metal."

The following is the brief and quaint account of the origin of the Birmingham brass works, given by Hutton the local historian: — "The manufacture of brass was introduced by the family of Turner, in about 1740: they erected works at the south end of Coleshill-street. Under the black clouds which arose from this corpulent tunnel, some of the trades collected their daily supply of brass; but the major part was drawn from the Macclesfield, Cheadle, and Bristol companies.

"Brass is an object of some magnitude in the trades of Birmingham; the consumption is said to be (in 1819) 1000 tons per annum. The manufacture of this useful article had long been in the hands of few and opulent men; who, instead of making the humble bow for favours received, acted with despotic sovereignty, established their own laws, chose their customers, directed the price, and governed the market. In 1780 the article rose, either through caprice or necessity, perhaps the former, from 72*l.* a ton to 84*l.* The result was, an advance upon the goods manufactured, followed by a number of counter orders, and a stagnation of business.

"In 1781 a person, from affection to the user, or resentment to the maker, perhaps the latter, harangued the public in the weekly papers; censured the arbitrary measures of the brazen sovereigns, showed their dangerous influence over the trades of the town, and the easy manner in which works of our own might be constructed. Good often arises out of evil; this fiery match, dipped in brimstone, quickly kindled another furnace in Birmingham. Public meetings were advertised, a committee appointed, and subscriptions opened to fill 200 shares, of 100*l.* each, which was deemed a sufficient capital: each proprietor of a share to purchase one ton of brass annually. Works were immediately erected upon the banks of the canal, for the advantage of water carriage, and the whole was conducted with the

true spirit of Birmingham freedom." The old companies hereupon sank the price from 84*l.* to 56*l.* a ton.

The copper used in the manufacture of brass in this country, is in the form called *shot*, having been granulated by pouring, when in a liquid state, into a vessel of water. The calamine, or ore of zinc, must be reduced to powder by means of a powerful stamping-mill, after which it must be washed and sifted to free it from earthy impurities, as well as from the lead with which in some form or other it is frequently found mixed. Thus pounded, the ore is mixed with broken charcoal, or with small pit-coal, and thoroughly calcined; the mass being frequently stirred, and the action maintained by the burning of larger pieces of charcoal arranged upon an open hearth, as the foundation of a stratified pile raised over the fire, by which the process is carried on. The calamine, thus freed from volatile impurities, as well as moisture, is further reduced by grinding with a small portion of charcoal. In this state it is mixed with the copper, the mass being firmly compressed into a crucible, capable of holding about 1 cwt. of the metal when melted. The compound must now be exposed to a degree of heat sufficiently intense to melt the copper; but as the calamine is very volatile, it would almost entirely fly off during fusion unless the crucible were closed at the top: this is effected by luting it carefully with a mortar of sand, clay, and horse dung. The pot thus charged and plastered over is ready for the furnace.

The brass furnace is constructed so as to receive a draught from the ash-hole below, the cavity for the reception of the crucibles and the fuel, communicating with the chimney by flues, to which dampers are fitted for the regulation of the heat. The form of this cavity is circular, narrower at the top than the bottom: to the top is adapted a moveable cover, consisting of fire-bricks enclosed in an iron frame, and which serves the founder as a sort of register, to increase or diminish the

intensity of the fire by the admission or exclusion of the air. At the bottom of the furnace is a strong perforated plate of cast iron: upon this the crucibles, charged as above described, are placed; and a quantity of furze, heath, or such like matters thrown in, to prevent the fuel from lying immediately upon the covering of the pots, which is thus allowed time to harden before the combustion becomes sufficiently intense to dissipate the zinc. Considerable care is required in this respect, in order not to fume away the peculiar properties of the calamine, before the copper is in a state to absorb them; as, however, the copper, when kept at a red heat, becomes penetrated by the calamine; so, in the latter state, it melts much sooner than before: but different qualities of the mineral require various degrees of heat. From ten to twenty hours, according to circumstances, are allowed for the complete fusion and mixture of the brass in the furnace. The crucibles on being lifted from the furnace, are uncovered, and any scoria which may be floating on the surface of the metal is skimmed off, after which the contents are poured into cast-iron ingot moulds, or other receptacles, according to the purpose required.

The following was the method of making brass plates at Stolberg, near Aix-la-Chapelle, at which place there were thirty-eight manufactories at work, at the end of the last century. These works were erected at Stolberg, on account of the proximity of rich mines of calamine: the immense quantities of copper consumed in the manufacture were derived from Norway, Hungary, Sweden, Germany, and Cornwall; that from Cornwall and Norway being esteemed the best. The crucibles were composed of argillaceous earth, mixed with the fragments of old crucibles calcined: they were $1\frac{1}{2}$ inch in thickness, 15 inches high, and 9 inches wide at the mouth. Into each crucible they introduced 40 pounds of copper broken into small pieces, 65 pounds of calamine well pulverised, and double its bulk of pounded charcoal. Eight crucibles, thus filled, were placed in

one furnace, and a vehement fire of pit-coal kept up about them for twelve hours. A workman then lays hold of each crucible with a pair of tongs, and throws i forcibly upon a bed of sand, in order to form a hole, into which the matter is made to run; the scum and charcoal being skimmed off, the contents of the pot are poured out, and form a mass termed *arkost*: it is brass of a coarse, brittle, and unequal texture, which must be subjected to a second fusion in order to be rendered perfect. The same crucibles are again employed, and the pieces of arkost are intermixed with charcoal and calamine, two or three pounds of old brass clippings being likewise introduced. In about three hours the pots are withdrawn, and their contents poured between two blocks of very hard granite, so as to form a plate. These blocks are 5 feet long, 3½ broad, and 8 inches thick: they are washed and rubbed with cowdung in the intervals of casting, the upper one being raised for this purpose by means of a pulley. Hoops of iron of different dimensions are adapted to the inferior stone, which serve to confine the metal and to determine the thickness of the plate: they are inclined a little at the time of pouring to facilitate the entrance of the liquid. From 40 pounds of copper, 60 of calcined calamine, and twice its volume of pulverised charcoal, the Stolberg melters derived about 50 pounds of brass. The plates were either exported, or cut with shears and drawn into wire, a good deal of which was required for the use of an extensive pin manufactory in the commune. Besides the above methods of converting copper into brass by a fusion of the metal, after being mixed when in a granulated state with pounded calamine and charcoal, the same object has been effected by what is called dry cementation, and which consists in exposing shreds of copper at a red heat to the fumes of zinc, until the former is sufficiently saturated with the latter, to have acquired a fine yellow colour, and at the same time to retain the requisite degree of malleability.

It is by a process analogous to that last described,

that the article known in commerce as brass leaf, tinsel, or gilding metal is made; the material being copper, beaten out into very thin plates, and afterwards rendered yellow. The German artists, particularly those of Nuremberg and Augsburg, are said to possess the best method of giving to these thin plates of copper a fine yellow colour like gold, by simply exposing them to the fumes of zinc, without any real mixture of it with the metal. These plates are planished and disposed of in the state of tinsel; or, after being cut into small pieces, they are beaten out like gold leaf, put into coarse books, and sold at a low price for the spurious sorts of gilding.

Cheadle, in Staffordshire, has long been noted for producing a fine yellow brass, particularly in the article of wire, or in large sheets, 3 or 4 feet in length, and from 2 to 3 feet wide. These large sheets are rolled from plates cast between two smooth granite tables; the undermost one having a raised margin of iron to confine the metal and determine the thickness of the plate, in a way similar to that practised at Stolberg. In Birmingham, the brass intended for rolling is run into cast-iron moulds, the ingot weighing from 20 to 30 pounds; and as this is frequently but little extended in width during the laminating process, the sheet, when thin, is often upwards of 20 yards in length; it is neatly rolled up in the manner of a riband, and tied with wire for the convenience of carriage. A great deal of the Birmingham sheet brass, being composed of shruff or old metal, with other economical ingredients, is very inferior in colour and ductility to that from Cheadle: it is, however, much cheaper than the latter, and will stand the fire better in soldering.

Several compound metals have at different times been introduced to the notice of manufacturers as approaching nearer to the colour of gold than common brass: to these at one time were given the denomination of Tombac, as indicative of a mixture of a deeper red than Pinchbeck's metal, which was very fashionable some

years ago. It may be here mentioned that, among the various projects set afloat in 1678, under the patronage of prince Rupert, was one for the manufacture of the yellow brass afterwards known as prince's metal. This was deemed so valuable a compound, that in the above year the well-known Temple water mill was erected on the river at Hackney, for the casting and boring cannon of this metal.

CHAP. XI.

BRASS OR BRONZE FOUNDERY.

ALLOYS OF COPPER OR BRONZE. — RELATIVE QUANTITIES OF METAL USED IN CASTING GUNS, BELLS, AND STATUES. — REMARKABLE INSTANCES OF MUTATION IN SOME WORKS OF BRONZE. — ANTIQUITY AND USES OF BELLS. — REAUMUR'S THEORY OF THE FORM OF BELLS. — CHINESE GONG. — LARGE BELLS, — IN CHINA, — IN RUSSIA, — IN ENGLAND. — DESCRIPTION OF THE GREAT BELL OF MOSCOW. — THEORY OF THE SONOROUSNESS OF BELLS. — NEW FORM OF BELLS. — PARTS OF A BELL. — CASTING LARGE BELLS. — MENDING CRACKED BELLS BY EXCISION. — BRASS CANNON. — CASTING AND BORING. OLD FOUNDERY IN LONDON. — BRONZE STATUES. — CORINTHIAN BRASS. — EARLY METAL EFFIGIES. — GREAT SKILL REQUIRED IN THE CASTING OF BRONZE FIGURES. — FORMING THE MOULD. — DRYING. — POURING THE METAL. — CAST IRON RECOMMENDED FOR STATUES. — COMPOSITION OF BRONZE, AND PRECAUTIONS RELATIVE TO THE ERECTION OF GREAT WORKS.

ALTHOUGH it is by no means proper, according to the strict meaning of metallurgical terms, to consider all alloys of copper as brass; yet, when speaking of such metals generally, with reference to their use in the manufactures of the country, it is more convenient to throw them together under a common denomination, than to repeat, in reference to each, the details of processes which, as in the particular of casting, belong, with certain modifications, to all; the more so when the comprehensive term *brazen* is applied to these alloys in a sense so well understood. Of compounds of this description, differing from that produced by the mixture of zinc or its ores with copper, may be here particularly mentioned bell metal, gun metal, and statuary metal or bronze, each of which is very often not only poetically, but popularly, and even in commerce, designated by the generic term brass, and of

which metal indeed, articles of the three above-mentioned kinds are sometimes really cast. These three classes of works constitute an exceedingly important item in the consumption of alloyed copper. The relative quantity of metal used in each department, however, varies greatly at different times. At present, the preponderancy is divided between the bell-founder and the statuary, the balance being greatly in favour of the former, the perfection to which the casting and boring of iron ordnance has been brought of late years, and especially the long-continued state of peace in which this country has reposed, having rendered the founding of brass guns almost an extinct manufacture. During the latter part of the sixteenth and former part of the seventeenth centuries, immense quantities of metal were consumed in these arts. The equestrian and other statues of our Jameses and Charleses, as well as of William III., together with the large amount of brass cannon cast during the wars of the last-named monarch, might almost justify the appellation of "an age of bronze" to the seventeenth century.

The fluctuations as to the relative weight of metal consumed for the above purposes respectively, and as occasioned by political or civil changes, are not more surprising than some of the incidents by means of which the material of one work has been recast in the formation of another, as prejudice or expediency may have influenced public or private opinion. Every one recollects the trick by which the fine equestrian statue of Charles I., now erected at Charing Cross, and said to have been the first ever executed in this kingdom, was preserved from the melting pot. It was cast in 1633, by a French artist; but not having been erected on the breaking out of the civil war, it was sold by auction by the parliament, with strict orders that it should be broken to pieces. Revats, a brazier in Holborn, purchased it, and advertised that he would melt it and make knife handles, &c. of it. He, in fact, caused bronze articles to be made and exposed for sale at his

shop, and thus made a fortune ; but after the Restoration he produced the statue, which had been concealed under ground, and it was erected where it now stands. An equestrian statue of James II., executed by an artist of the name of Sarson, under the approbation of sir Christopher Wren, at an expense of 800*l.*, for the town of Newcastle-upon-Tyne, fared worse as to the original design, while it was fated to a still more remarkable mutation as to the ultimate use of the material. During a riot, when that town declared for the Prince of Orange in 1688, the statue being an obnoxious object to the mob, they first threw it down, and then with ropes dragged it into the river. It was afterwards weighed up from the water, and on the petition of two parishes, to one of which was adjudged the metal of one of the horse's legs, the whole was given to be cast into bells. The appropriation of brass guns for the casting of statues is very common ; and an object which strikes a visiter on entering the premises of Chantrey the sculptor, much more forcibly than even the ponderous blocks of fine marble, is, the tier of brazen cannon piled on one side of the yard, and ready to be transferred to the furnace as the artist may have occasion to rival or to repeat in bronze any of those figures which confer increasing celebrity on the name of the first living sculptor. The bronze statue of Achilles, in Hyde Park, erected in honour of the duke of Wellington, and his brave companions in arms, was cast from cannon taken in the victories with which the name of his grace is so intimately associated.

Some singular instances of mutation of the kind referred to have also taken place in France. Hazlitt, in his "Life of Napoleon," states that the cannon taken at Austerlitz were not all made use of to erect the column in the Place Vendôme. M. Gaudin, minister of finance, came to Napoleon to demand a score of these cannon for his own use. "What then," exclaimed the emperor, "is our minister of finance going to make war upon us?" "No," replied the duke de Gaëta, "not upon

you, but on some villainous old machines that kill the workmen in the mint; and if your majesty will give me twenty of these cannon to reconstruct the beams of the engines, I will have the name of Austerlitz engraved upon them." This appeal prevailed; M. Gaudin had the cannon placed at his disposal; and these engines are still used to stamp the heads on the coin of the present king of the French. Of the casting of cannon from church bells we have many examples, particularly in some of the provinces of France during the Revolution.

BELLS.

The origin of bells, as connected with churches, is involved in considerable obscurity; ecclesiastical, as well as other writers who mention the subject, repeat the early opinion that the first bells of this description were made about the year A. D. 400, at Nola in Campania; from which places, it is added, they derived their Latin names *Nolæ*, first used by Quinctilian, and *Campanæ*, a term adopted in the time of St. Jerome. The value of these plausible derivations has, however, been disputed in favour of the more modern invention of large bells, of the existence of which, before the sixth century, it is contended we have no positive evidence. Bede first mentions large bells in England, about the year 670; and two centuries afterward, they may be said to have been common. In 870, according to the historian of Croyland, one of the abbots of that religious house gave to the church thereof a great bell, which he named Guthlac, and afterwards six others, which were all rung together. Donations of bells were always acceptable to monasteries and churches, and before the Reformation they were often baptised and named with great ceremony; the crossing, blessing, lustration, &c. being performed by the bishop.

From the first, church bells appear to have been cast

with circumscriptions in relief, either containing the name of the saint to whom they were dedicated, or of the individual by whom they were presented; in some cases, mottoes or sentences of moral import appear; indeed, there is scarcely a local history of any parish in the kingdom, of which the monograms, or legends of the bells, do not form an item. Weever, in his "Funeral Monuments," gives the following distich as indicating the various uses of bells:—

> "Funera plango, fulgura frango, sabbata pango,
> Excito lentos, dissipo ventos, paco cruentos."

The use of bells of a small size, is of great antiquity, not only in the performance of the services of religion, but for other purposes; in the Jewish ceremonies of the tabernacle, and afterwards in the temple, bells of gold were attached to the blue robe of the high priest. Among the Greeks and Romans, *tintinnabula* were used for the purposes of giving warning or of calling attention, much as they are at present used by most of the modern nations of Europe. Of the form of these ancient bells, or the circumstances by which it was determined, we have no particular information: M. Reaumur has a curious observation on this subject, in the Memoirs of the Paris Academy. He assumes that, as pots and other vessels more immediately necessary for the service of life, were made before bells, it probably happened, that the observing these vessels to have a sound when struck gave occasion for making bells, intended only for sound, in that form. This, however, he remarks, appears not to be the most eligible figure; for lead, a metal which is, in its common state, not at all sonorous, yet becomes greatly so, on being cast into a solid hemispherical segment, such as is found in the ladle in which melted lead has been allowed to cool: it has been contended that, if this shape alone can give sound to a metal which in other forms is mute, how much more must it necessarily give it to other metals naturally sonorous, in whatever form: and M. Reaumur observes,

that if our forefathers had possessed opportunities of being acquainted with the sound of metals in this shape, such would probably have been the form of our bells at present. Whatever may be thought of this theory of the form of bells, the conclusion come to is contrary to fact. It is true, a hemispherical piece of lead, an insonorous metal when cast hollow, does ring a little on being struck with a key; but a lump of brass, a material which is very sonorous in the ordinary bell form, is only slightly so when solid. The Chinese gong is an instrument of this class, though differing in its form no less from the solid hemispheres of M. Reaumur, than from that of bells in general; being shaped like a large tambourine, and producing when beaten with a mallet, slowly at first, and then with rapid strokes, an exceedingly deep sound. It is a very brittle bell metal, but malleable at a temperature much under a red heat; and appears on analysis to be composed of eighty parts of copper and twenty parts of tin.

The largest bells in the world are, according to travellers, in China and Russia; at Nankin formerly hung four bells of such enormous size that, although not swung, but only struck with a wooden mallet, they brought down the tower, and have long lain neglected among its ruins. One of these bells is about twelve feet high, seven and a half in diameter, and twenty three feet in circumference. It has a swelling in the middle, but does not expand much towards the rim, where it is seven inches thick: from the dimensions of this bell, its weight has been computed at 50,000 lbs, or more than double the weight of that at Erfurt, said by father Kircher to be the greatest bell in the world. In the churches of Russia there are numerous bells, and some of them very large: one of these, in the belfry of St. Ivan's church at Moscow, weighs 127,836 lbs. This was the largest bell known, until Boris Godunof gave to the cathedral of that city a bell weighing 288,000 lbs. This was again surpassed by the bell cast at the expense of the empress Anne, and which weighs at the lowest

estimate 432,000 lbs. This is the largest bell in the world: its height is upwards of 21 feet; circumference near the bottom, more than 67 feet; greatest thickness 23 inches. This bell is likewise on the ground; the local tradition being, that the beam upon which it was suspended in the tower was accidentally burnt, in 1737; this statement, however, is denied by some travellers. By its fall, the bell suffered a fracture towards the bottom sufficiently large to admit two persons abreast without stooping. In England the biggest bells are Christ-church college, Oxford, 17,000 lbs.; St. Pauls, London, 11,474; and Great Tom of Lincoln, 10,854 lbs.; the heaviest of these being considerably less than one twentieth of the weight of the Russian bell.

The numberless bells of Moscow, says Clarke in his Travels, continue to ring during the whole Easter week, tinkling and tolling without harmony or order. "The large bell near the cathedral is only used on important occasions, and yields the finest and most solemn tone I ever heard. When it sounds, a deep and hollow murmur vibrates all over Moscow, like the fullest tones of a vast organ, or the rolling of distant thunder. This bell is suspended in a tower called the belfry of St. Ivan, beneath others, which, though of less size, are enormous; it is 40 feet 9 inches in circumference, 16½ inches thick, and it weighs more than 57 tons. The *great* bell of Moscow, known to be the largest ever founded, is in a deep pit in the midst of the Kremlin. The history of its fall is a fable, and as writers continue to copy each other, the story continues to be propagated: the fact is, the bell remains in the place where it was originally cast: it never was *suspended*. The Russians might as well attempt to suspend a first-rate line of battle ship with all its guns and stores. A fire took place in the Kremlin, the flames of which caught the building erected over the pit in which the bell yet remained; in consequence of this the metal became hot, and water thrown to extinguish the fire fell upon the bell, causing the fracture which has taken place. It reaches from the

bottom of the cave, where it lies, to the roof; the entrance to the cave is by a trap-door, placed even with the surface of the earth. We (Messrs. Clarke and Cripps) found the steps very dangerous, some of them were wanting and others broken, which occasioned me a severe fall down to the extent of the whole first flight, and a narrow escape for my life in not being dashed upon the bell: in consequence of this accident a sentinel was stationed afterwards on the trap-door, to prevent people becoming victims to their curiosity. He might have been as well employed in mending the steps, as in waiting all day to say they were broken. The bell is truly a mountain of metal: they relate that it contains a very large proportion of gold and silver; for that, while it was in fusion, the nobles and the people cast in as votive offerings their plate and money. It is permitted to doubt the truth of traditionary tales, particularly in Russia, where people are much disposed to relate what they have heard without once reflecting on its probability. I endeavoured in vain to assay a small part; the natives regard it with superstitious veneration, and they would not allow even a grain to be filed off; at the same time it may be said the compound has a white shining appearance, unlike bell metal in general: and perhaps its silvery appearance has strengthened, if not given rise to a conjecture respecting the richness of its materials. On festival days the peasants visit the bell as they would a church, considering it an act of devotion; and they cross themselves as they descend and ascend the steps leading to the bell. The bottom of the pit is covered by water, mud, and large pieces of timber, which, added to the darkness, render it always an unpleasant and unwholesome place, in addition to the danger arising from the steps which lead to the bottom. I went frequently there, in order to ascertain the dimensions of the bell with exactness: to my great surprise, during one of those visits half a dozen Russian officers, whom I found in the pit, agreed to assist me in the admeasurement; it so nearly agreed with the

account published by Jonas Hanway that the difference is not worth notice. This is somewhat remarkable, considering the difficulty of exactly measuring what is partly buried in the earth, and the circumference of which is not entire. No one, I believe, has yet ascertained the size of the lower rim of the bell, which would afford still greater dimensions than those we obtained, but it is entirely buried in the earth. About ten persons were present when I admeasured the part which remains exposed to observation. We applied a strong cord close to the metal in all parts of its periphery, and round the lower part where it touched the ground, taking care at the same time not to stretch the cord. From the piece of the bell broken off, it was ascertained that we had thus measured within two feet of its lower extremity. The circumference obtained was 67 feet $5\frac{1}{3}$ inches. We then took the perpendicular height from the top of the bell, and found it correspond exactly with the statement made by J. Hanway, viz. 21 feet $4\frac{1}{2}$ inches: in the stoutest part, that in which it should have received the blow of the clapper, its thickness equalled 23 inches: we were enabled to ascertain this by placing our hands under water, where the fracture had taken place, which is about 7 feet high from the top of the bell. The weight of this enormous mass of metal has been computed to be 443,772 lbs., which, if valued at *3s.* per pound, amounts to *66,565l. 16s.*, lying unemployed and of no use to any one."

As the practice of bell-ringing is cultivated as a science in England, so the casting and tuning of bells have attained a very high degree of perfection. Although the music of bells consists exclusively in what is termed melody, yet the effect of that variety of changes in which the tasteful ringing of a peal of tunable bells is made to consist, is extremely delightful to most persons. Bells are ranked by musicians among instruments of percussion; and their sounds are conjectured to consist of a vibratory motion of the parts, producing thereby pulsations on the air in the manner

of a musical chord — the instrument, in fact, on being struck by the clapper, undergoing a real change of figure, and returning to it again by a succession of tremulous vibrations. M. Perrault maintained that the sound of the same bell or chord is a compound of the sound of the several parts thereof, so that where the parts are homogeneous, and the dimensions of the figure uniform, there is such a perfect mixture of all these sounds as constitutes one uniform, smooth, even tone; the contrary circumstances producing harshness. This he infers from the bells differing in tone according to the part struck; and yet, strike it any where, there is a motion of all the parts. He therefore considers bells as composed of an infinite number of rings, which, according to their different dimensions, have different tones, as chords of different lengths have; and that, when struck, the parts immediately struck determine the tone, being supported by a sufficient number of consonant tones in the other parts.

The usual form of a tower bell is well known; the proportions, however, of the several parts may be very materially altered, while general outline remains the same. These proportions do in fact differ according to different theories; their composition, therefore, constitutes one of the chief secrets of the bell foundery. Mr. Harrison, a bell founder at Barton-upon-Humber, has adopted some novel contours, having for their object the producing the greatest degree of sonorousness, with the least weight of metal. This individual, in an Introduction to an intended "Treatise on the Proportions of the constituent Parts of Bells, and on the relative Proportions of Bells of different Degrees of Acuteness and Gravity," professes to have discovered the elements of a more scientific formula than any other that is known. "This new science," he says, "comprises the elements of the proportions of the component parts of bells, and the relations of bells of different tones to each other, which have been hitherto utterly unknown." There is another class of bells, which has lately been

discovered by Mr. Drury, the vibrations of which depend upon the most simple principles. These bells are destitute of curvature, their sides being quite perpendicular, and the shape very similar to an ordinary tub.

Although bells differ in shape as well as in size, these conditions are not left to chance or to the workman's notions of form and symmetry in the application of any given weight of metal, but are measured according to a scale or diapason in use among the founders; the proportions, however, differing much in different hands — and still more widely from those observable in foreign bells. The parts of a bell are, 1. the sounding bow, properly the brim, terminated by an inferior circle which grows thinner and thinner; 2. the brim, technically so called, or that part upon which the clapper strikes, and which is usually thicker than the rest; 3. the waist, or furniture, and the part that grows thicker to the brim; 4. the upper vase, or that part which is above the waist; 5. the pallet, which supports the staple within; 6. the bent and hollowed branches of metal on the crown, uniting with the cannons to receive the keys, by which the bell is suspended to the wheel or beam. The clapper, which in Europe is made of iron, with a large knob at the striking end, is not commonly mentioned as a part of the bell, when technically spoken of. The bell founder's business may be divided into three parts: — 1. the proportions of a bell, which are simple and relative; the former pertaining to such an agreement of the parts as shall render it sonorous; the latter to establish a requisite consonance between several bells; 2. the forming of the mould; and 3. the composition and melting of the metal.

In forming a scale or profile, from the proportions of which to strike the circumference of a bell, according to the ordinary pattern, the modern rule has been to make the diameter fifteen times the thickness of the brim, or part on which the clapper strikes; the height twelve times; and the superior diameter of the upper vase, or

top of the bell, half that of the bottom of the rim or widest part. The thickness of the cap which strengthens the crown, and to which the ears are cast, is about one third the thickness of the brim, and the ears or hollow branches themselves one sixth of the wider diameter of the bell. The different proportions being carefully laid down upon a plan, in semidiameters, a large pair of compasses is required, to traverse, from a fixed centre, the circumference of the bell, in order to apply the scale during the moulding. These compasses consist of two different legs, one made to move on the top of a stake or stationary centre; the other longer, and convenient to be applied to the work, as it proceeds, of moulding the bell; these legs are connected by a cross piece, to detain them in any given position.

For the casting of a large bell a hole or pit must be dug sufficiently capacious to allow the workmen to traverse the mould of the bell during its formation, and so deep, that the metal flowing from the furnace may flow to the top of the casting: if several bells are to be cast at once, the excavation will be proportionately large. In the centre of this hole a stout stake is firmly fixed, supporting an iron peg, on which, as on a pivot, the shorter branch of the compasses is made to turn. About the bottom of this stake, and of the proposed bell's diameter, a circular wall of brick-work is raised, about two feet in height, and technically called a millstone. A body of bricks as a foundation for the core, or that part of the mould which is to determine the form of the bell inside, is now raised about the stake: this is afterwards covered over with successive layers of fine cohesive earth and sand, mixed with horse-dung, the compasses being frequently applied to determine and regulate, by means of a moulding board attached, the size and rotundity of the work. After the core has received one coating or so, a fire is kindled in the inside, which is left open for that purpose to dry the work, and by which the stake is, of course, consumed. When the first plastering of the core is completely baked, and

cooled, other coatings of the cement are successively laid on, and in like manner smoothed by the sweep of the compass board, and afterwards thoroughly dried, and retouched to smoothness.

The core being completed, the compasses are rearranged, so as to describe the outside size of the bell, and being again placed, the workman begins to form what may properly be considered as the model of the bell about to be cast. This part of the work consists of a mixture of moulding loam and hair, which is plastered all over the core at intervals, several of the last layers being but thin coats; the board of the compasses being passed over the surface to make it exactly smooth and true. The last layer of the model is a mixture of wax and grease spread over the whole; and the inscriptions, or other ornaments, which are either made of wax, or metal moulds waxed over, are applied to the surface. The next operation is, to form the shell, or that part of the mould which is to give its figure to the outside of the bell; this is done by now moulding upon the last-mentioned body which had been covered with wax. The first layer of this final coating is composed of earth sifted very fine, mixed with cow-hair to make it cohere, and tempered with water to a state of semi-fluidity, when it is poured upon the model, and readily sinks into the interstices of the ornaments, as well as covers the model very exactly. Two or three of these coatings having been applied, a fire is again lighted in the core, by which the shell is dried, and the wax, leaving its impression in the sand, melted off. After this, other layers of the moulding-loam are laid on, a quantity of hemp being spread intermediately to bind the mass more securely together; the compasses are still employed, in order to secure a degree of equality in the thickness of the shell. The ears are moulded separately, and the parts affixed, when the mould is afterwards made up, and the iron staple to support the clapper inserted.

When the moulding is completed, and all the parts

sufficiently dry, the hollow of the core is filled with sand; the opening through the head of the shell, afterwards to be filled with the moulding of the ears, affording a space for that purpose. Five or six pieces of wood, two or three feet long, are placed about the millstone, and under the lower part of the shell: between these and the mould wooden wedges are driven to loosen the model and the shell: the latter being lifted off, and the former broken, and removed from the core, the shell, after being blackened inside by the burning of straw to give smoothness to the casting, is lowered exactly over the core; the cap containing the perforations for the rings or ears is affixed; vents are made for the escape of air, and admission of the metal; after which the whole is carefully surrounded in the pit with sand, well rammed about the shell. A gutter being made from the furnace, in which the metal is in a state of fusion, it is suffered to flow into the mould in the pit, and fill it in every part. Bell-metal is a compound of copper and tin, which becomes not only more sonorous, but heavier than either of the ingredients apart. The proportions differ; ordinarily, however, 23 lbs. of tin are mixed with 100 lbs. of copper — the latter being somewhat increased when the bells are larger. Brass, spelter, and even lead are sometimes added — and more rarely silver, which is considered much to improve the tone of the metal. The writer recollects, on one occasion of the casting of a heavy tenor bell to complete a peal in a large town, that numbers of the inhabitants who went to see the operation cast silver money into the furnace, though, whether to an amount sufficient to affect the mass, is uncertain.* It is only, of course, in

* In some parts of Germany the casting of a bell is made an affair of much ceremony, and sometimes of interest to a whole neighbourhood. Schiller's "Song of the Bell," in which the poet has interwoven a description of the various processes of the foundery, with suitable reflections, is an exquisite composition, of which three or four English versions, including one by Lord Leveson Gower, have been printed. An eminent antiquary has informed us, that this flower of German poetry is commonly implanted at an early age in the memories of such individuals as, in Germany, are considered to possess a liberal education. "This," the gentleman lluded to remarks, "is perhaps the highest compliment which could be

the casting of very large bells, or sets of bells, that it would be necessary to pursue the method above detailed; those of a less size, and of which models can be kept, may be moulded in the manner of large iron pots, in boxes made to separate laterally. Of house bells, and those for the hand, so beautifully turned inside and out, large quantities are manufactured at Birmingham. While falconry continued in vogue in this country, hawk's bells were often mentioned in commerce.

When a bell is cracked, it is generally considered to be irremediably spoiled, and beyond the reach of any ingenuity to repair it, though the following entry from the churchwardens' account of St. Margaret's, Westminster, might almost seem to justify the conclusion that some of our old braziers occasionally made the attempt: — "1558, paid the tinker for mending the second bell, 8*s*."

Some instances having of late years occurred, of the restoration of church bells to their original tone by the excision of the fractured part, an experiment for that purpose, under the direction of Mr. Bishop, of Birmingham, was undertaken in 1831, upon "Great Tom," in Lincoln cathedral, the crack in this instance being somewhat in the form of a T.

In the first instance it was attempted to cut out the injured part by means of sawing; but it was soon found that such was the extreme hardness of the metal that no saws could be obtained of sufficient temper to work for any length of time with effect. The workman then set up a machine in the belfry for the purpose of drilling a series of holes, intending afterwards to break these

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paid to a work of genius; and I endeavoured," he adds, "to recollect any similar instance in the range of English poetry. We have excerpts in abundance, which every person is expected to know familiarly; and we have a few shorter poems which every one knows well by heart; but I think there is no instance of a poem of the length of Schiller's Song which Englishmen can be expected to commit to memory, not even 'Lycidas,' or the 'Christmas Hymn,' or 'Alexander's Feast,' though any one of these might bear a comparison with that truly admirable work."

one into the other by means of wedges. During the performance of this latter operation, in the tracing one side of the flaw, a large piece of the rim or skirt was suddenly broken off in the contrary direction, weighing 6 cwt., and about 8 feet in length: the experiment was then abandoned as hopeless. It may be mentioned that several years before, the noted Van Butchell gave it as his opinion, that if a hole was drilled through the bell at each end of the crack it would restore it to its former sound: this plan, however, was not attempted.

BRASS CANNON.

Some authors have asserted that Henry VII. was the first of our sovereigns who attempted to cast cannon in his own dominions, but with little success. Larry, an authority generally quoted, ascribes the invention of brass cannon to an individual of the name of Owen; he asserts there were none such known in England till the year 1535, and that iron cannon were, for the first time, cast in this country in 1547. Lord Herbert nearly agrees with the former of these dates, but differs from the latter; "it was," says he, "in the year 1534 that great ordnance of brass were first made in England, they having before been had from foreign parts." Iron guns, however, were probably much earlier: at all events, great cannon, and probably, as Macpherson thinks, of iron, had been made before that time in the castle of Edinburgh by a Scottish artist, Robert Borthwick, who used to inscribe upon them, —

"Machina sum Scoto Borthwick fabricata Roberto."

It seems more reasonable to conclude that the cannon alluded to were of brass. Seven large guns, called the

"seven sisters," and made by the above-named artist, were famous in Scotland in the seventeenth century.

The method of casting great guns of brass differs but little from that adopted in casting ordnance at the iron foundery in general. They are in both sorts moulded from a pattern embedded in sand in two oblong caissons of iron, separable longitudinally, and admitting of subsequent closing by means of projecting pegs and ears. Cannon are always cast of a taper form, or somewhat of the frustrum of a cone, the thickest part being the breech, where the greater force of the gunpowder is exerted, at the moment of ignition. It has been laid down as a rule, that if the bore at the mouth be two inches, the breech must be six inches in diameter; the length of the piece is estimated by calibers taken at the muzzle; one caliber of six inches requiring a length of twenty calibers; or, if the diameter of the bore be six inches, the depth of the gun would be ten feet. The composition of gun metal varies even more than that used in the casting of bells; the following are understood to be the common proportion of the ingredients:—to 100 lbs. of copper we add 10 lbs. of tin; or to 240 lbs. of old metal are put 68 lbs. of copper, 25 lbs. of common brass, and 12 lbs. of tin. The Germans are said to mix their gun metal according to the following formula:—to 4200 lbs. of metal fit to cast again they add $368\frac{33}{41}$ lbs. of copper, $204\frac{13}{41}$ lbs. of brass, and $307\frac{30}{41}$ lbs. of tin. The French are reported to use for gun metal the proportions of 100lbs. of copper to from 6 lbs. to 10 lbs. of common brass, and from 9 lbs. to 15 lbs. of tin. The composition was greatly varied by different founders and in different countries.

The boring of brass guns is effected by apparatus similar to that described in a former volume for boring iron ordnance; viz. while the piece is made to revolve in collars, one near the mouth, and the other near the breech, the drill meanwhile being urged to its work by means of a rack. It was formerly the method to bore the piece in an upright position; at present, however,

it is placed horizontally, so that, while the boring proceeds, the outside is at the same time turned throughout its length with the proper tools. As brass is so much softer, or, as the workmen say, *kinder* to turn than iron, a quicker revolution is communicated to the gun; the boring instrument, meanwhile, as it may be ground to a thinner edge, making its way much more easily in the former than in the latter metal.

About the end of the seventeenth century, there was a large establishment in Moorfields, where were cast the cannon belonging to government, and which place afterwards acquired a very different celebrity as the "Old Foundery," so often mentioned by the Rev. John Wesley and his followers as their chief place of worship in London. Its history is thus given in the Annals of Methodism:—"As many persons were anxious to see the fusion of the metal, running it into the moulds, &c., there were erected, in this foundery, galleries for the accommodation of spectators. About the year 1716, the old cannon, taken from the French by the duke of Marlborough, were ordered to be recast: which circumstance excited considerable interest, and collected a greater number of visitors than usual, amongst whom was Andrew Scalch, a founder, and a native of Switzerland. As it was understood that he was a foreigner travelling for improvement in his profession, he was allowed to examine the preparations. He observed that the moulds were not sufficiently dry, and communicated the circumstance to the principals of the department; warning them, at the same time, of the danger of an explosion, from the dampness being converted into steam while the red-hot metal flowed into the moulds. Due enquiry was made by those who superintended the preparations; but, piqued by the superior sagacity of a foreigner, they treated his warning with contempt, and the casting was ordered to proceed. The fatal explosion occurred, as Scalch had predicted: the liquid metal flew in every direction; a great part of the building was destroyed, and several lives were lost. In conse-

quence of this painful event, it was determined to erect a new foundery on Woolwich Warren; the entire control and management of which were entrusted to Scalch. The foundery in Moorfields continued long in a tenantless and dilapidated state, till, in November, 1739, Mr. Wesley took a lease of it for 115*l.*, and expended a considerable sum in fitting it up for public worship."

BRONZE.

The casting of statues in bronze, although in strictness belonging rather to the fine than to the useful arts, may, nevertheless, with propriety, be briefly noticed here. This art, which requires for its exercise not only the ingenuity of the statuary, but the experience of the metal founder, is of great antiquity, and the few works of Greek and Roman execution which time has spared, attest that the skill of the ancient bronzists has not been overpraised. Specimens of their works in tripods, vases, lamps, &c. are preserved in the various European museums. The nature of the heathen mythology was no less favourable to the multiplication than to the perfection of statues; and these not merely of marble but of metal: indeed, the wealth of some ancient cities is said to have been estimated by the collective value of their brazen figures; and Delphos, Athens, and Rhodes, are reported to have each possessed 3000. The latter place was particularly famous for the colossal image which bestrode the entrance of the harbour, and which is said to have been thrown down by an earthquake, B.C. 224, and which the Saracens, on their becoming possessed of the island, sold to a Jew, who loaded 900 camels with the brass. The Romans were not less distinguished for ornamenting their public edifices with statues than the Greeks; and so strong did the propensity become for multiplying works of this kind, that it was a common saying, in Rome the people of brass were hardly less numerous than the Roman

people: and this proverb will hardly seem hyperbolical if we believe what is asserted of Marcus Scaurus, who, though an ædile only, is said to have adorned the circus with more than 3000 statues of brass, during the time of the celebration of the Circensian shows.

In what manner the ancients carried on their operations in obtaining casts from statues or models, we are not informed; neither is it known exactly what was the composition of the metal they used. Bronze, composed of from eight to twelve parts of tin, combined with 100 parts of copper, becomes an alloy much harder than copper, less liable to rust, and so fusile as to run thin, and be easily cast in a mould. Copper, differently alloyed, formed the metal of which the ancients seem to have cast their statues and vases of the ordinary kinds. The Egyptian bronze, we are told, consisted of two-thirds brass and one-third copper. Pliny says, the Grecian bronze was made by adding one-tenth lead, and one-twentieth silver, to the two-thirds brass and one-third copper of the Egyptian bronze. For works, however, of the highest class, the Corinthian brass has been famous in all antiquity: its discovery is thus detailed by the historians. L. Mummius, having sacked and burnt the city of Corinth, in the 158th Olympiad, or 146 years before Christ, it is pretended that this precious metal was formed from the immense quantity of gold, silver, and copper with which that city abounded; which, being all melted and mixed together by the fierceness of the fire, composed, as it were, a new metal. The statues and vessels which were afterwards made of it by excellent artists, were esteemed of great value; the preciousness of the material vying with the beauty of the workmanship. Those who affect to give an account of this metal distinguish three sorts of it: in one gold was predominant; in the next silver; and, in the last, gold, silver, and copper were in equal parts.

There are few arts which require greater skill, and the intimate knowledge of more numerous particulars, than the casting of first-rate works in bronze. In the

life of Benvenùto Cellini, the celebrated Italian artist, written by himself, there are some curious details connected with the moulding and casting of a large figure of Perseus, as well as concerning other works of a like kind. The use of brass, for statuary purposes, in this country, is referred, by antiquaries, to the thirteenth century. The brazen effigies of Eleanor, queen of Edward I., king Edward III., and his son the Black Prince, — the first among female figures, and the latter among armed men, are reckoned the earliest specimens of their age in England. But the original character was not that of a single shining metal; they were superbly painted, gilt, and enamelled. A taste for metallic statues has never much prevailed in Britain; nor can it, perhaps, be said that the art of casting them has attained to the most exalted success. Many splendid works have, however, been executed.

In the modern bronze foundery, the mould of a statue consists of three parts: — 1. the core, or that by means of which the inside is cast hollow, to save metal, and diminish the weight of the figure; 2. the wax, in which every exterior portion of the statue is modelled, so as to render exactly the features, anatomical details, and all that belongs to costume or ornament; and, 3. cement for the shell or mask, which, deriving all its impressions from the wax, communicates them afterwards to the metal itself. The core is a rude representation of the figure intended to be cast, and smaller, in every part, in proportions agreeing with the calculated thickness of metal: if large, or having extended parts, it is strengthened inside by means of pieces of iron. It is composed of a mixture of gypsum and brickdust diluted to the consistence of clay, and must be raised upon a fixed grate, in order that it may be thoroughly dried, and for another purpose afterwards mentioned.

A rude outline of the statue being thus raised and supported, and thoroughly dried, it is next covered over with modelling wax; which should be, in all parts, at least an inch thick: this the artist with his tools

fashions exactly to the form which the casting is to exhibit, the perfection of the ultimate design, of course, corresponding to the degree of excellence attained in the model. If, however, the statue is to be a fac-simile of one already executed in marble, or modelled in plaster of Paris, moulds of the latter material are formed upon the pattern figure, and from these moulds castings in wax are obtained of convenient sizes, and these are joined together upon the core; the workman proceeding from the feet upwards, and filling up every cavity inside as he advances, by pouring in a liquid cement. By the former method, it will be perceived, every line of the moulding must be executed by the sculptor himself, so as to form an original work; in the latter, an artist who could not execute a design at all from the beginning, may, with proper attention to the copying merely, produce, in metal, a master-piece of statuary. In either case, we have the entire form of the intended bronze composed externally of wax: to this are now to be attached several nearly perpendicular sticks of wax, intended to form conduits for the passage of the molten metal, as well as vents for the escape of the air during casting: bits of bronze are likewise stuck through the wax into the core, so as to keep both parts of the mould in their relative position after the wax has been drawn out. When these are arranged, the formation of the shell or outer covering is proceeded with: it is composed, in the first layers, of a mixture of clay and old white crucibles, very finely pounded, sifted, and moistened to about the consistency of cream: this is carefully spread several times over upon the wax, so as to fill every indentation, and cover every raised part: to this composition, earth and horse-dung are afterwards added; and, lastly, a thick coating of these two materials only is laid on. The whole is now firmly fixed to the grate by means of uprights, and bands of iron embracing the shell at intervals. Every precaution having been taken to secure the stability of the mould, a fire is kindled under the grate, and the wax melted

out, leaving the space which it occupied to be filled with the metal. When, however, the mould is prepared in several parts, from a model first accurately formed in gypsum, and afterwards cut up into sections of convenient size, the pieces may be dried separately. The oven in which Mr. Chantrey dries his moulds is about fourteen feet long, twelve feet high, and twelve feet broad. When it is raised to its highest temperature, with the doors closed, the thermometer stands at 350°, and the iron floor is red hot. According to sir D. Brewster, the workmen often enter it at a temperature of 340°, walking over the iron floor, with wooden clogs, which are, of course, charred on the surface. The same authority tells us that, on one occasion, Mr. Chantrey, accompanied by five or six of his friends, entered this furnace, and, after remaining a few minutes, they brought out a thermometer which stood at 320°. The mould being thoroughly dried, is, whether entire or composed of several pieces, hoisted, by means of a crane, into the casting pit, and, having been put together and properly placed, it is carefully surrounded with sand: if the subject be too big to allow of the mould being thus lifted, then all the preceding operations would have to be carried on in the pit. The mould being thus placed, and gutters made from the furnace to communicate with the different conduits leading to various parts of the statue, the metal is suffered at once to flow into and fill the mould, which it does almost instantly. As it is difficult to obtain very large statues perfectly sound, especially towards the feet or the part lowest in the pit, they are sometimes cast in several pieces, which are afterwards united by pouring metal, in a state of fusion, along the joints. The work, whether cast at once or in sections, is finished by cutting off superfluous portions, and chiseling the different parts, as may be necessary for correctness and effect: after which the surface is sometimes rendered of uniform appearance by the aid of some composition, according to the taste of the artist.

In one of the numbers of the Philosophical Journal for 1833, there is an article on the casting of statues, in which the writer recommends the employment of the founder, whose acquaintance with the best methods of moulding in sand, and mixing as well as managing the metal, would give him many advantages over the statuary, whose attention to the latter department is not only at the expense of his more direct professional occupation, but at the still more serious account of those who patronise him. As the casting of statues is an affair of copying merely, in which the utmost success of the bronze founder can never enable him to surpass his model, or depreciate the legitimate merit of the sculptor, which lies essentially in the perfection of the original design, it does appear probable that the chance of greater success, as well as the certainty of a vast diminution of expense, would be found in a division of the art of making bronze statues, between the sculptor and the caster. The same writer, adverting to those exquisite figures of cast iron which are brought from Berlin, and are imitated in some other places, suggests the desirability of multiplying the designs of the sculptor by means of the iron caster's art in this country; such articles being well adapted, from their strength and durability, to supply the place of many less interesting but indispensable architectural and other supports. As the material is so cheap, its application in the way proposed might tend to increase a taste for, and thus foster the patronage of the arts of sculptural design with reference to our mortuary and other monuments. One principal objection to the use of cast iron in this way is, its tendency to rapid oxidization; so that, in so humid a climate as ours, it would be difficult to preserve cast-iron statues in damp or exposed situations. Probably, a strong gilding or bronzing would remedy the evil, to say nothing of other methods of preservation that might be devised, if the taste for figures of this kind were to become general.

Iron is sometimes found necessary, in connection with

bronze, for the construction of some monuments or trophies, especially for military weapons, where the ordinary material might be too brittle: in this case, it is necessary to protect them, or they will rust away, as we sometimes witness. In 1813, sir Humphry Davy being in Paris, was consulted by M. Alavair, the architect, upon some points relative to the colossal elephant of bronze, which was intended to form a part of the fountain then erecting on the site of the Bastile. The English chemist, in reply, says: — "Ten parts of copper to one of tin is an excellent composition for a work upon a great scale, nor do I believe any proportions can be better. There is no fear of any decay in the armatures, if they can be preserved from the contact of moisture; but, if exposed to air and moisture, the presence of the bronze will materially assist their decay. Wherever the iron is exposed to air, it should, if possible, be covered with a thin layer of bronze. Where the iron touches the foundation of *lead*, it should, in like manner, be covered either by lead or bronze. A contact between metals has no effect of corrosion, unless a Voltaic circle is formed with moisture, and then the most oxidizable metal corrodes; and iron corrodes rapidly, both with lead and bronze."

CHAP. XII.

LACQUERED BRASS WORK.

CONVENIENCE OF BRASS FOR A VARIETY OF MANUFACTURES IN SMALL WARE. — INTRODUCTION OF THE BRASS TRADE INTO BIRMINGHAM. — VARIOUS OPERATIONS. — CASTING SMALL ARTICLES. — BOXES, SAND, AND MOULDING. — PATTERNS. — DRYING THE SAND MOULDS. — MELTING AND POURING THE METAL. — CASTINGS. — STAMPING MACHINERY. — PICKLING WITH VITRIOL AND AQUAFORTIS. — BURNISHING BRASS WORK. — LACQUERING. — BRONZING.

Under the above denomination may be comprehended that immense variety of articles for which, within the last 150 years, Birmingham, in particular, has become so celebrated. London, Sheffield, and some other places, do, indeed, vie with Birmingham in the beauty and excellency of many of the manufactures in brass; but, in the cheapness, diversity, and extent of its productions, the latter town is unrivalled. Its artizans have not only met the demand of the times, but have, by their inexhaustible ingenuity, actually created a taste, in the gratification of which the comforts of society are amazingly increased, and thousands of industrious individuals enabled to obtain a reputable livelihood; and all this, in addition to those sources of wealth which have, at the same time, been opened up by an extensive traffic with foreign parts.

Notice has already been taken of the introduction of the manufacture of brass into the town, where the consumption of that metal had become so considerable; and it is natural to look with curiosity towards that earlier period when its use, as an important staple, was introduced into Warwickshire. But, however interesting it might be to know something in detail respecting the local rise and progress of an art of so much consequence to Birmingham, and, indeed, to the whole country,—for there is, probably, not a house in England,

much less a hardware shop in the United Kingdom, where brazen articles are not found, — yet, we learn little or nothing on this subject from Hutton, who thus briefly despatches his chapter on brass foundery: — "The curious art before us is, perhaps, less ancient than profitable. I shall not enquire whose grandfather was the first brass founder here, but shall leave their grandsons to settle that important point with my successor who shall next write the history of Birmingham. Whoever was the first, I believe he flourished in the reign of king William; but, though he sold his productions at an excessive price, he did not, like the moderns, possess the art of acquiring a fortune; but, now, the master knows the way to affluence, and the servant to liquor."

The operations through which brass work, in general, passes in the workshops, are casting, filing, chasing, stamping, soldering, screwing, pickling, turning, burnishing, and lacquering. Many articles are perfected by one or two of these operations; others require more; and, in some cases, all of them are combined in the production of things of absolute cheapness and beauty.

The more massy productions in brass, and especially those in which strength or solidity is exhibited, in connection with that style of getting up which may be called the natural grain, or surface of the metal, as being left untouched by the tool, are, for the most part, cast. Among articles of this class may be mentioned, figures of men and animals, either fully brought out, or exhibited in various degrees of relief; heads and claws, such as are frequently seen on door-knockers, fenders, &c.; and especially those elegant diversities of foliage or scroll work, appropriated to brackets, lamps, pillars, and other wares: these are not only among the heaviest and most durable, but, in some respects also, the handsomest results of the trade.

In the brass foundery two sorts of sand are used: the first of a coarse description, similar to that used by the

iron founders, and which serves well enough for the casting of such articles as are afterwards to be finished by filing or turning; fineness of cast surface being, under these circumstances, of little consequence, as compared with despatch in the moulding and running of the pieces. The using of this material for moulding is called casting in the *green sand*, as, from the comparative openness of its body, however solidly embedded or rammed, and while quite moist from the hands of the workman, the liquid metal may be poured into it without any danger of explosion. The other material used by the moulder, in casting the finer sorts of articles, and particularly such as are not to be either filed or turned on the surface, is Trent sand, or some equally fine substance, well pulverised and sifted, and moistened with the grounds of beer, in such a degree as may cause it sufficiently to cohere in the moulding, without, at the same time, sticking to the models, or afterwards swerving from that accuracy of impression which they ought to impart to it.

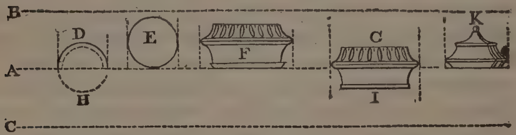
The casting boxes are two oblong frames, two or three feet long, and ten or twelve inches wide, and, in depth, proportioned to the thickness of the articles intended to be cast. These boxes, as they are called, may either be made of iron, or of wood, clamped and faced with iron: the latter material, however, will only answer for casting in green sand, as the Trent sand requires to be exposed to a degree of heat, in the drying of the moulds previous to casting, which would be destructive of wooden boxes. These frames have, on the edges, projecting ears, furnished with pegs and holes to correspond; so that they can be fitted accurately together, or may be separated, and again replaced with the greatest exactness. To these boxes belong two well-seasoned boards, an inch or two larger in surface than the boxes; and, besides these boards, two clamp screws contrived to pass over the boxes and boards together, so as to keep the whole firmly and closely united, while the metal is poured into the moulded sand.

When the sand, mixed with wort upon the stone casting table, has been thoroughly pounded or tewed, by means of a short, thick, wooden roller, the workman places one of the boxes upon the moulding board, and also arranges thereon the models of the articles to be cast, or parts of the same, which must all be of such a shape as that they will admit of being withdrawn, without difficulty, from the sand. The models, if of a small size, are disposed on either side of a strip of metal, intended to leave, after its removal, a common gutter for the stream of liquid metal, which is admitted to each article by a little side cut, made by scraping out a groove in the sand, slanting downward from the midrib or perpendicular gutter. The models thus arranged are, with the board, dusted over with some of the sand burnt and pulverised, after which a quantity of the moulding sand is thrown in by means of a wire riddle, so as to distribute it softly and uniformly upon the models; and, as soon as they are completely buried, more sand is taken and pressed down, with the hands, until the box is full; after which the sand is rammed firmly in with the end of the wooden roller or tewing stick. A metal strike is then drawn over the box, by which the superfluous sand is removed, and a level surface presented, upon which the other board is placed, and the box turned over. The first board is then removed, and the models are seen embedded in the sand, their hollow or reverse sides being now uppermost. The other box, or, more properly, half box, is next placed upon the one already filled, the pins and holes keeping them steady: the models and sand surface are well dusted, the sand riddled, kneaded, beaten in, and stripped off as before. The spare board being again placed upon the box, the workman strikes smartly upon both boards with the stick, so as to start or loosen the models in the sand, after which the last mentioned half of the mould box is carefully lifted off, and the board applied to the surface of the other, which, being lifted off likewise, leaves the models and the midrib upon the

board: such of them as do not come away in this manner, are picked out of the sand by means of an instrument resembling a pair of ordinary sugar-nippers. The little side canals, or other connecting lines, having been scraped in the sand, the boxes are, if containing Trent sand, reared over the fire to dry; or, if filled with green sand, then closed for the immediate reception of the metal.

It must be obvious, however, to every one who attentively marks the foregoing particulars, whether at all conversant with the operations of casting or not, that only such models would leave the sand with ease, as were of a certain shape, *i. e.* all the parts of which sloped in one direction inside and outside. Suppose A (*fig.* 31.) to represent the surface of the first board

Fig. 31.



used in moulding, and also the line of contact between the surfaces of sand when the boxes are closed, and from A to B and C sections of the depth of sand: a hemispherical article, as D, would very easily leave the sand, as will be instantly apparent from the vertical dotted lines: but in moulding a ball, or flat circular article with a swell or flange about it, recourse must be had to another contrivance. If the ball E, or the rim F were placed upon the board as shown in the cut, and sand rammed upon and about them, it would be impossible on turning up the box to get the models out of the sand, until so much of it had been removed as occupied the spaces below the widest parts of E and F, which would, of course, destroy the impression in the sand to that extent. But if models of only half each article, as D and G, are moulded in the first box, and the entire

models substituted on moulding the second box, the articles will readily leave the sand both ways, and the impression be divided between the two bodies of sand as shown by H and I. Sometimes, when the reverse part of an article is only trifling, as in K, the caster, on turning up the first box, smooths away with his finger whatever sand may have got below the flange, the place of which is occupied by a portion of that in the second box. If a ball, or other like article is intended to be cast hollow, there is a stem, or projection on the model suitable in length and thickness to a piece of wire, or a small rod, upon which is moulded in a proper metal mould a core of sand or clay, corresponding to the inside of the ball; this, when the model is removed, and the boxes closed for casting, is placed in the cavity of the sand, so that the metal flows round it; and when the boxes are opened the wire is withdrawn, and the matter of the core picked out of the ball. It is by a similar arrangement in the moulding that brass heads are cast upon nails, window screws, and other things.

The moulding boxes being properly prepared, either by drying or otherwise, for the reception of the metal, they are first dusted over with bean flour, and then carefully closed, the boards placed on the outside of each, and the whole bound firmly together by means of clamp screws, as represented below (*fig.* 32.) The

Fig. 32.

boxes thus made up, are afterwards reared against some prop, in a position inclining a little from the perpendicular, in order that when the melted brass is poured in, it may, without falling at once to the bottom, freely

flow downward, as well as run laterally, until every cavity be filled. The brass-founder uses a small air furnace, the draught of which is increased by closing the opening above it with a door of sheet iron. The crucibles are either the blue pots from Germany, or more commonly those made of Stourbridge clay, and of sizes proportioned to the weight or number of the articles to be cast at one heat or pouring. When the metal is properly liquefied in the melting pot, the latter is lifted from the furnace by means of a pair of tongs, the bits of which embrace the vessel, and after clearing off the cinders which float upon the surface, its contents are poured into the moulding boxes through an opening at *A*, answering to the head of the canal in the sand. During this operation, a blue sulphureous flame arises, and sometimes breaks through any crevice in the boxes, which, unless they be well closed, suffer the metal to escape likewise, and causes the articles to be surrounded with a jagged excrescence or *fash*. If the metal be too hot when poured, or of a bad kind, the castings will contain little cavities, or be, as the founders say, *blown*; if, on the other hand, it be not sufficiently liquefied, the articles will not receive a sharp outline from the sand, and sometimes be found but partially cast. When the whole has become sufficiently cool, the boxes are opened, the castings taken out of the sand, and cut from the midrib and each other, the wasters and connecting pieces being again transferred to the crucible.

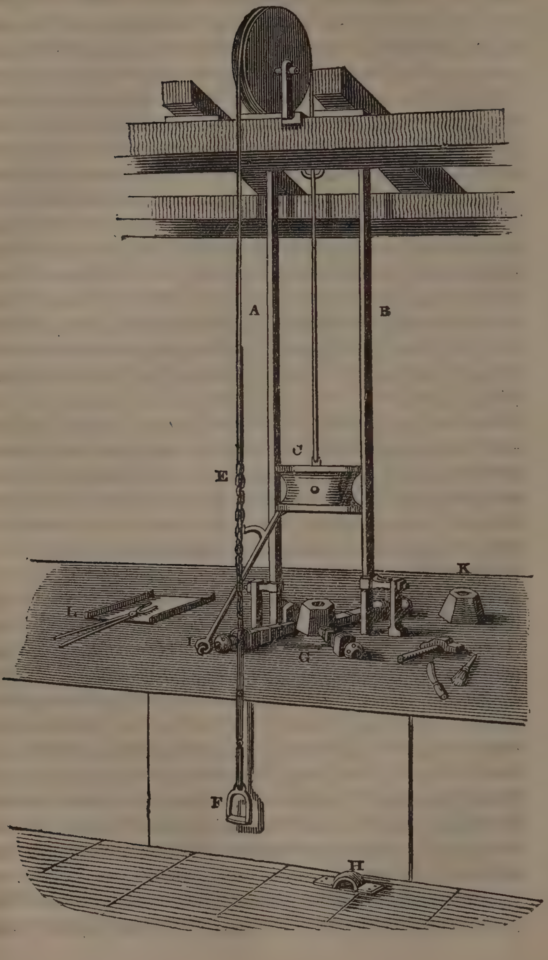
The castings are now trimmed on the edges and elsewhere by filing, and afterwards, by turning or otherwise, brought to the state required. In some sorts of work, the figured parts, requiring to appear deep or sharp, are chased or dug out by the aid of steel chisels; in others, a matted or lined style is produced on the metal by means of punches or rollers of corresponding design.

A large portion of the Birmingham brass work, and especially that description for which the artizans of that town are so justly famous, consists of articles of sheet metal figured by stamping. This art, by means of

which, at a single stroke, or at most within a single minute of time, an effect is produced on metallic laminæ, which, by the tedious methods of chasing or embossing formerly practised would require thousands of strokes, and many hours, or evén days to produce, belongs altogether to modern ingenuity. And although the expense of the apparatus is very considerable, — including dies, often enormously so,—yet such is the facility of multiplying impressions by this method, and so light, yet stiff the body of metal embossed, that the low price of many brass ornaments of this description would be scarcely conceivable, were it not that cheapness and demand have reacted upon one another until the articles have become universally requisite. The following is a representation of the stamp, which, with some trifling differences in size, &c. is used not only by the brass-worker, but also by the silver-plater, and the Britannia-metal smith.

In the representation of the stamp (*fig.* 33.) A B are two square upright pillars of wrought iron, about eight feet high, and so placed that their angular edges serve to guide the hammer C in its ascent and descent, its ends being grooved for this purpose. This hammer, which is eighteen inches across, and weighs about 100lbs. is suspended by a rope passing over the trundle D, at the top of the room: at E, it is tufted with worsted in the manner of a bell rope, to form a handhold, and at the lower end is attached a stirrup F; in this the workman places his left foot, the right being thrust under the loop H, during the operation of raising the stamp. G is a large boss of cast iron, having on its face four stout screws to detain the die: this boss is let into a block of stone, weighing from one to two tons. The stamp hammer C is sometimes changed for one heavier or lighter, according to the description of work: to accommodate such hammer, the upright pillars are attached at the top to two beams, and at the bottom to two side screws, by which contrivance they are readily brought nearer together or removed further apart. On

Fig. 33.



the under face of the hammer is fixed a flat piece of iron cut on the surface like a rasp, and called a "lick-up:" its use is, to detain the piece of lead corresponding to the die, and by means of which the material to be impressed is struck into the die; each stroke keeps this lead fast to the lick-up, from which it is, when done with, separated by striking it downwards. When the stamp is not in use, or during the fixing or alteration of the die, the hammer is propped up by the spanner I. A separate die is represented at K; and at L, the tray and nippers used when articles are stamped while red hot, which is often the case with copper and plated metal, though never with brass.

The dies of the brass stamper, and which vary in size and weight according to the bigness of the article to be operated upon, are made either of steel or cast iron; of the former material, when small, or when the metal is required to be embossed into designs of very sharp execution; and of the latter, when the pieces are large, and, as is generally the case, intended to be afterwards got up with the burnisher on the smooth, and aquafortis on the other parts. Whatever the size, if the metal be thin, and the relief of the design inconsiderable, especially when the parts are roundish, a very few strokes with the stamp are sufficient to produce the impression. But it is far otherwise, when the figure is of considerable depth, and exhibiting strong angular sections; under these circumstances, the greatest care is required on the part of the workman, not only to select good metal, but likewise to imbed it in the die only by gentle strokes, and these oft repeated, sometimes from a dozen to a score; the metal being frequently lighted, or heated red hot, at intervals during the stamping. If these precautions were not attended to, it would be impossible, even with the most ductile sheet brass, to proceed far without fracturing the article, and thus wasting both time and metal.

Some of these stamped pieces are afterwards formed into rings or tubes, or attached to castings by means of

spelter solder, as in the making of lamps, umbrella furniture, &c.; others are united by screws, as in bell-pulls; many are used nearly as they come from the stamper, as door plates, escutcheons for locks, and roses of all sorts; others, being lapped by the edges upon a disc of iron with a brass stem, as in the beautiful variety of curtain pins, have the appearance of being very massy and substantial, when, in reality, they are exceedingly light.

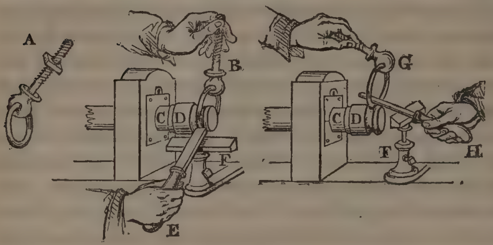
Cast or stamped articles, being properly fitted or dressed, are next to undergo that process which gives to them their beautiful yellow colour, and prepares them to receive a coating of lacquer. To free them from whatever grease they may have contracted, and otherwise to render the surface more favourable for the action of acid, they are heated slightly red hot, and afterwards, in some cases, laid to pickle in diluted spirit of vitriol. On being taken out of this menstruum, they are washed in water, and by means of a brush, sometimes made of wire, the dirt and scurf cleared from the surface, the stamped sheet metal appearing more or less yellow, according to the quality of the brass; and so of the castings, though they are not unfrequently of a reddish colour. Having undergone this preparatory cleaning, the next process is to dip them separately in aquafortis, by means of a pair of brass nippers. If the acid be good, and the metal in a proper state, a very hasty immersion is sufficient to give to the latter that clean, rich appearance so strikingly characteristic of the best Birmingham wares. Experience enables the operator to judge as to the best mode of dipping, as well with reference to the qualities of the brass, as to the strength of the acid: in general, if the work be taken out too suddenly, it is but partially cleaned, and if suffered to remain too long, it becomes red or black; these defects are sometimes removed by reimmersion. Immediately on the metal coming into contact with the acid, dense noisome fumes of a stifling quality are plentifully evolved; so that it is usual to place under a shed or in some open room the

dipping vessels, which should be of the best Wedgwood ware, ordinary red pottery, however well glazed, being soon acted upon by the menstruum. On being taken from the aquafortis, the article is well washed, and then placed in water in which argol has been dissolved, to prevent the metal from tarnishing: it is finally placed among hot dry sawdust, until all moisture is dried off, and the surface, on being brushed and cleaned, is of the colour intended. Brass ornaments, which have become black by use and exposure, may be cleaned by immersion in nitric acid, as above described; every particle of grease, and all remaining lacquer being first removed by the application of boiling pearlash water with a soft brush; care to be taken at the same time to detach, or, previous to dipping, to guard with varnish any portion of iron-work.

The smooth parts of both cast and stamped articles, particularly when circular, are in the former sort, first turned with steel tools, and in both sorts burnished at the lathe: as a figure of this engine, as used by brass turners, will be given in another page, it is unnecessary to describe it here. It is to the lustre produced by this burnishing, in contrast with the dead appearance of the other parts, that many Birmingham articles are so much indebted for their beauty. The burnishing tools are sometimes made of an extremely hard blood-stone — the pieces being fitted to proper handles, and sometimes of steel; they are very variously shaped, according to the form of the body to be operated upon. Hence the terms round-end, parrot-beak, flat, circular, and clog-burnish, are common: the last-named instrument, which is used in burnishing large articles, particularly convex surfaces, consists of a long iron lever, having a handle at one end, and at the other a hook working in a staple affixed to a block of wood, in the manner of a clog-maker's knife. In burnishing flat or mixed articles, they must be placed so as to lie solid and firm; in those which admit of being stuck or screwed upon wooden or metal chucks, the mode of

operation must be very readily conceived; annular articles may likewise with equal facility be burnished all over, by first placing them within, and then upon such chucks. Brass rings, which pass through knobs of the same metal, are more difficult to get up. A (*fig.* 34.),

Fig. 34.



represents a ring and screw-stem of this description, such as are frequently used for drawer handles (it need scarcely be mentioned that the ring, whether a casting or made from strong wire, is soldered after having been passed through the hole in the knob or head of the screw stem); B, the article in the position in which it is held during the burnishing of the outside of the ring; C, the engine nose, bearing the chuck D, which has a hollow or groove near the end, in which the ring lies; E, the flat burnisher; F, the rest. It will be apparent, on inspecting the cut, that by holding the ring as represented, and pressing it against the revolving chuck with the burnisher, the ring will revolve too without any impediment of the stem, while, by giving it an oblique leaning both ways, three fourths of the outer surface may be easily burnished. G shows the method of holding the ring for burnishing the inside; and H the polished steel tool by which it is pressed upon the revolving chuck, and the lustre imparted. Alegar is sometimes used to prevent the metal from being scratched by the friction during burnishing, and as improving the

effect. It is likewise necessary that the burnisher should be kept clean by repeated rubbing upon a piece of soft buff leather powdered with crocus martis; otherwise, by the adherence of minute portions of the surface of the brass to the steel, the latter will rather tear and scratch, than burnish the article to which it may be applied.

Brass work, of the sorts above described, is finally lacquered or bronzed. The lacquer is thus prepared:—To a pint of rectified spirits of wine put one ounce of turmeric powder, two drachms of the best annatto, and two drachms of saffron; let it stand ten days in some rather warm place, shaking the bottle often during that time: filter it through coarse muslin into a clean bottle; then add three ounces of clean seed-lac, and shake the bottle frequently for ten days; after which it must be allowed to settle, when it will become fine and fit for use. Articles to be lacquered, being perfectly clean, and especially free from all grease, must be heated either in a stove adapted to the purpose, or on a piece of nearly red-hot iron, until they are just above the temperature at which they can be held in the fingers. The lacquer is then applied, either by means of a camel-hair brush, or by dipping the articles; the former method being always pursued when the work is important: they are then returned to the heater for a minute or two, by which means the lacquer becomes thoroughly dried on.

Various methods are adopted by different manufacturers for giving to brass articles that peculiar appearance known by the appellation of bronze. The following recipes are taken from an article on this subject, published in the *Glasgow Mechanics' Magazine*. The *green bronze* is thus prepared:—Take one quart of strong vinegar; half an ounce of mineral green; half an ounce of raw umber, half an ounce of sal-ammoniac, half an ounce of gum-arabic, two ounces of French berries, half an ounce of copperas, and about three ounces of green oats, if these can be procured; if they cannot, the preparation will succeed perfectly without them. Dis-

solve the different salts and gums in small portions of the vinegar; then mix the whole in a strong earthen vessel, adding the berries and the oats, over a gentle fire: bring the compound to boil: then allow it to cool, and filter it through a flannel bag, when the bronze will be fit for use.

The following is the bronze commonly used by brass-founders: — Take one English pint of strong vinegar, one ounce of sal-ammoniac, half an ounce of alum, a quarter of an ounce of arsenic; dissolve them in the vinegar, and the compound is fit for use. Some brass-founders merely use the vinegar and sal-ammoniac; and this cheap composition is said rarely to fail, when the metal is of good quality.

Bronze is used upon articles got up by any of the different processes common among the brass-workers, such as filing, turning, rubbing with sand-paper, or dipping in aquafortis. It is, however, absolutely necessary, in order to be successful, that the work be well cleaned, and, especially, free from grease. The bronzing must be performed with a small soft brush, and great care must be taken to keep the work constantly wet with the liquid, to prevent its turning green. When the colour which is wished has been attained, which will generally be in from twenty to thirty minutes, the work must be quickly washed in clean cold water, and then dried in soft warm sawdust, after which the whole is to be covered over with a coating of lacquer, which preserves the colours.

When it happens that, from the quality of the metal, the surface cannot by the former process be brought to a sufficiently dark colour, the following is recommended as a cheap and effectual method of communicating the required tinge:—Mix about a quarter of an ounce of the finest lamp-black with about one gill of strong spirits of wine, and strain the mixture throngh a fine linen cloth. The work on which the bronze has been already used must then be warmed upon a cistern plate, or over a clear fire, until it can scarcely be held in the

hand. Then, with a fine camel-hair brush, such as is used for lacquering, the work must be laid over with this mixture, in very thin coatings, until the shade required be obtained. When cold, it must be polished with a very soft brush, or piece of linen rag, dipped or moistened with clear green oil. A coating of lacquer is then laid over the whole, and the most beautiful bronze that can be produced on brass, will be by this means obtained; and if the work be not made too black with the mixture, nor the lacquer used of too bright a yellow, the bronze obtained will be a beautiful dark green; the colour so much used by the English brass-founders. By this it will be seen that any shade of what is called green bronze may be obtained, simply by using more or less of the blacking, and a lighter or darker colour of the yellow lacquer: and the different tints wished to be given to the work will of course be obtained by the different thickness of the coatings of blacking which the several parts of the work receive. The work, however, will stand much longer in colour, when the bronze can be made sufficiently dark without using the blacking at all, and this may be effected by the following method.

When either of the bronzes first described has been used, and the work dried as there described, if the shade should not appear so dark as is wished, let the work be placed before a smart fire, or in bright sunshine, where, however, no current of air passes. When thus exposed, let it be turned occasionally, and brushed with a soft brush. This plan will be found to produce a very fine bronze, after all other means have failed (with the exception of the blacking), but it is tedious, and, where time is an object, it will always be best to use the blacking.

CHAP. XIII.

LAMPS, BRASS TUBES, AND TURNING.

ANCIENT LAMPS. — CURIOUS LAMPS. — SPIRAL OR CANDLE LAMP. — TALLOW LAMPS. — ARGAND'S BURNER. — BRACKET LAMP. — SUSPENSION LAMP. — TABLE LAMP. — GAS LAMPS. — DIFFERENT BURNERS. — PATENT BURNER. — BRASS TUBES. — CUTTING OUT AND CLOSING. — SOLDERING. — PICKLING AND DRAWING. — DRAWING BENCH. — BRASS TURNER'S LATHE. — DIFFERENT SORTS OF TOOLS USED. — CUTTING SCREWS. — OVAL ENGINE. — ECCENTRIC AND CYCLOIDAL CHUCK. — CONTRIVANCES FOR TURNING WIRE.

One very ancient use of metal, especially of copper and its compounds, was in the making of lamps; and for the same purpose, in more recent times, the consumption of brass has been immense: indeed, amidst the fluctuations of science, manufactures, taste, and domestic convenience, it is a fact that brazen lamps have always been, as they still continue to be, in demand. Of the bronze lamps in use among the Egyptians, to whom their invention has been ascribed; the Greeks, Romans, and various other nations of antiquity, we have frequent mention in contemporary writers, while not a few of the articles themselves have been preserved by accident to the present day, and may be seen in museums, or by engraved representations in archæological works. Many of these brazen lamps appear, like the ancient candelabra, to have been of very elegant construction; little art, however, seems at any time to have been exercised in improving the principle, which in all was perfectly simple; namely, the immediate insertion of the wick, by means of a small tube, or merely through a convenient orifice, in a vessel containing oil. They would

in general present a large shadow. To obviate in some degree this defect, the body of the lamp was sometimes made with a projecting beak or spout, similar in shape to a butter-boat or cream-ewer; so that, by placing the wick in this part, the diffusion of the light was comparatively little impeded in one direction. The imperfect combustion of the matter drawn up to feed the flame must often have caused considerable smoke to arise, as every person may have observed in the burning of any old-fashioned lamp: hence we may conclude, that not only might the work of a tedious author incur the equivocal distinction "*lucernam olet,*" but himself and his study must literally have "smelled of the lamp;" and this unpleasant circumstance would likewise, as may be supposed, commonly attend the burning of ancient lamps in very different situations.

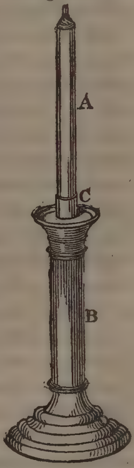
Besides the demand created for lamps in modern times for domestic and other ordinary purposes, they have been largely required for the services of religion, as well in this as in other countries. Travellers tell us that, in the city of Fez, there is a mosque in which 900 brazen lamps are kept burning every night: in Turkey also, and elsewhere, they are almost exclusively used in religious illuminations. The universal use of lamps in the Romish churches is well known; and the thuribule commonly used in the service of the altar, and derived from the Jewish censer, may probably have suggested the earliest form of some of our suspended lamps.

It is no wonder that in this country, where the arts had made such progress, and, especially, previous to the discovery of the economical application of gas, considerable attention should have been paid to the manufacture and improvement of lamps. Many of the articles so produced have been highly ingenious, some of them embodying the application of scientific principles, and others remarkable for their simplicity.

Besides the ingenious lamps devised or described by Cardan, Dr. Hooke, Mr. Boyle, Desaguliers, &c. and

hence bearing the name of these philosophers; we have others, in which the supply of oil is maintained at a level near the point of combustion, by causing it to float upon a fluid of greater specific gravity, as sea water: such was the principle of Mr. Barton's patent lamp. It will be obvious, however, that this and similar contrivances must always depend for their satisfactory performance too much on the careful management of the trimmer, to be generally esteemed: hence, a lamp that burns beautifully in the laboratory, will often totally fail in the kitchen: automaton lamps of a most ingenious construction have often amused the curious; but how rarely do we meet with them in use? The figure in the margin (*fig.* 35.) represents Proctor's patent spiral candle lamp; so called from its action and appearance combined. The tube A, which is called the candle, has, upon its lower end, a screw about an inch long, adapted to the inside of a tubular spiral worm, soldered within the pillar B, and reaching from top to bottom. In the centre of the pillar is fixed, by means of a knob at the bottom, a stiff upright wire, having on its upper end a plug of thick leather, fitted exactly into the candle tube A, so as to prevent the oil from flowing out at the bottom. The position of this plug being about equal to the height of the nozzle C, the candle tube, when raised to its height, as shown in the cut, may be filled with oil by taking out the burner at the top: this burner is made to hold a flat or a round cotton at discretion. As the oil is drawn up and consumed by the ignited wick, and whenever the lamp begins to burn faintly, a turn or two of the candle, by lowering it in the pillar, bring the wick into fresh contact with the oil, which shows itself upon the burner, and the light immediately

Fig. 35.



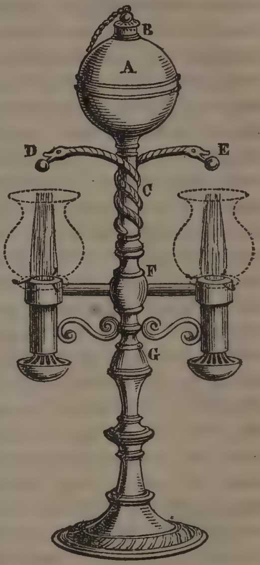
revives. This operation is repeated at intervals, till the top of the candle is almost down to the nozzle, and consequently, the only remaining supply of oil is in the tube between the plug and the burner. In this stage, the tube A requires to be again screwed back to its full height, and to be replenished with oil.

This ingenious lamp is of a handsome form, exceedingly portable, and casting little or no shadow; and might have maintained its place in the public estimation but for two capital faults: in the first place, it requires to be frequently turned about to keep up the oil; and, secondly, the candle tube insensibly becomes greasy, to say nothing of the difficulty of preventing all leakage about the plug. Many thousands of these lamps were, however, at one time manufactured, mostly of brass and of Britannia metal; and as the patent was for keeping up the oil to the cotton by means of a spiral screw to lower the candle, its security was invaded by making the lamp with a vertical sliding rod, upon which the plug, by the means of a small knob moving along a slit in the pillar, or by a rack and pinion, was raised and lowered in the tube A, which in these imitation articles was stationary. The increased difficulty of preventing leakage of the oil on this principle, and the dirtiness occasioned by its frequently exuding through the vertical slit in the pillar, tended materially to ruin the credit of this lamp.

Many savages, who resort occasionally to artificial illumination, burn for this purpose various descriptions of fat, into which they stick a rude wick of some convenient material. In some places, where the people have not acquired the art of working metals, the unctuous substance is placed in an earthenware or other vessel, during combustion; others carry their contrivance a step farther; and the writer has now before him a massive old lamp wrought out of lava by some ingenious artist of Tahite, one of the islands in the Southern Pacific: the design, although rude, is by no means devoid of taste, and the article, certainly a curiosity in its way, would

afford a striking contrast placed beside an elegant bronze lamp from Pompeii. The annexed engraving (*fig.* 36.) represents a neat lamp for burning tallow invented by Mr. Monnom, Broadway, Worcester, and concerning which several notices appeared in the Mechanics' Magazine, a few years ago. The burners are on the Argand principle, and contain a circular wick. A is the globular reservoir, into which a supply of tallow is introduced, by taking off the cover B. About the heater or hollow stem C, the metal serpents D E are entwined; their heads being so placed over the flame during the burning of the lamp, as to maintain, by the heat they communicate, the tallow in the stem at the temperature of fluidity, this object being obtained in the lateral tubes by the burners themselves. The reservoir may be unscrewed from the stem at F, previously to which it is necessary to give the globe A half a turn on the tube C, to shut in the tallow. The whole has a horizontal motion by means of a pin in the pillar at G. In relighting, a small solid heater is placed for a few seconds into the burner to set the wick with its screw at liberty. The manufacturer states that this lamp, with one pound of tallow, will continue to burn for eighteen hours, producing a light more than equal to eight candles of that weight.

Fig. 36.



One of the American scientific journals contains a description of a patent lamp for burning tallow, lard,

bees-wax, or other concrete oils, which appears to combine simplicity and cheapness in its construction. It is proposed to make the body of this lamp in the form of a common tumbler, with the cover, or upper part of it convex. Tubes with wicks are fixed in its centre in the ordinary way, and within the body of the lamp there is a cup, which is open at top, and may be about half the height of the shell or external case of the lamp. This cup, is borne up by a spiral spring, so that its upper edge is kept in contact with the cover of the lamp: from the centre of this cup a wire, which may be of copper, ascends, and passes through a hole in the centre of the burner, to which the tubes are attached; this wire is to rise so high that the flame of the wicks may heat it; which heat, descending, melts the concrete matter, being aided also by that portion which it communicates to the cup, and wire spring to which it is attached. When the lamp is to be filled, the wax, tallow, &c. in a melted state, is to be poured into it, so as not only to fill the cup, but the body of the lamp also. When the material is partly burnt out, and becomes too low in the cup to supply the wick, the wire heater is to be pressed, which, causing the cup to descend, will again fill it, and when the pressure is removed, the action of the spiral spring will restore it to its place. The points depended on by the patentee "are, the construction of the cup, spring, and heater," by which "the great difficulty of the tallow's getting low, and beyond the influence of the heat, is avoided." This combination is believed to be new, although the heater alone is not so, a copper, or other wire, having been frequently used to keep tallow, &c. in a melted state for burning in lamps. It need scarcely be remarked that, however, useful and economical these lamps may be in some cases, they are not to be expected to possess the additional recommendations of being smokeless and inodorous.

It would, however, be tedious to enumerate the various modifications of form and action to which the

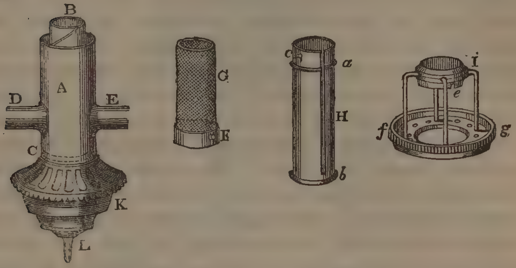
oil lamp has been subject, previous to its arrival at what may deemed its perfect construction by Argand. The discovery of the mode of applying a new principle by this individual, not only produced an entire revolution in the manufacture of the article, but threatened with ruin all those whom the patent excluded from participation in the new trade; so much so indeed, that Argand, who had not been apprenticed to the business, was publicly persecuted by the tinners, locksmiths, and ironmongers, who disputed his right by any improvements to infringe the profits of their chartered vocation. "This invention," to quote a description of the lamp published some years ago, "embraces so many improvements upon the common lamp, and has become so general throughout Europe, that it may be justly ranked among the greatest discoveries of the age. As a substitute for the candle, it has the advantage of great economy and convenience, with much greater brilliancy; and for the purpose of producing heat, it is an important instrument in the hands of the chemist. We may, with some propriety," continues this authority, "compare the common lamp and the candle to fire made in the open air, without any forced method of supplying it with oxygen; while the Argand lamp may be compared to a fire in a furnace, in which a rapid supply of oxygen is furnished by the velocity of the ascending current. This, however, is not the only advantage of this valuable invention. It is obvious that, if the combustible vapour occupies a considerable area, the oxygen of the atmosphere cannot combine with the vapour in the middle part of the ascending column. The outside, therefore, is the only part which enters into combustion; the middle constituting smoke. This evil is obviated in the Argand lamp, by directing a current of atmospheric air through the flame, which, instead of being raised from a solid wick, is produced from a circular one, which surrounds the tube through which the air ascends."

The mechanism of the Argand burner, in its present

improved state, will be clearly understood from the annexed figures and explanation, which apply equally to each description of the lamps hereafter described.

A (*fig.* 37.) is a brass tube, about $3\frac{1}{4}$ inches in

Fig. 37.



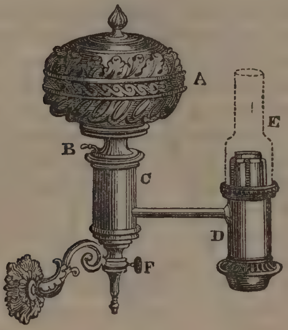
length, and $1\frac{1}{4}$ inch wide: within this tube is placed another, B, which is soldered fast inside by the flange at C: the space between these tubes contains the oil surrounding the wick, and which, being freely admitted from the reservoir by the side pipes D E, rises in the tubular space, either to a height corresponding with its level in the reservoir, or at least so as to maintain the wick in a state of constant saturation. The tube B is of considerable thickness, having a spiral groove cut about it from top to bottom: F is a metallic ring made to slip over the tube B; it contains a short pin inside, which fits exactly into the spiral groove just mentioned: G is the circular woven cotton wick, the lower end of which is drawn tight upon the neck of the ring: H is a copper tube, with a slit nearly from top to bottom: it admits the ring F, and being dropped over the inner tube B, exactly fits the inside of the wider tube A, by means of a narrow rim near the top at *a*, and another at the bottom *b*: between the upper rim and the margin, there is a small projecting pin *c*, which, when the whole apparatus is combined, fits into the cavity *e* of the collar I. To prepare the lamp for use,

the tube H is placed between A and B as just described: the ring F, with its charge of cotton, is next inserted, the pin in the inside falling into the spiral groove, and that on the outside entering the slit in the tube H, which, on being turned about, moves the ring F down upon the screwed inner tube, until the wick only just rises above the superior edges of the tubes, in the interval between which it lies in the oil. In this stage, the frame I is placed on, the nick in the collar at *e* falling upon the pin near the top of H: the lower disc *f g*, passing over the tube A, at once presents a convenient support for the glass chimney, and a finger-hold for raising the wick. The central tube is open throughout, communicating, at its lower end, with the brass receptacle K; the latter is perforated at top, to admit the air which, by circulating through the above tube, and the hollow flame which surrounds it, causes the lamp to burn with that pecular freedom and brilliancy which distinguish the Argand construction. This last-mentioned receptacle likewise catches any small quantity of oil which may pass over the inner tube, during the combustion of the wick. L is the brass peg, which fits into the upper part of the pillar, in the table lamp.

In addition to the endless variety of small portable lamps, the peculiarities of which it would be tedious to particularise, and the merit of which, as compared with those on the Argand principle, consists, for the most part, in their cheapness, the more important articles, and those generally in demand, may be distinguished as fixed or bracket lamps, suspended or chandelier lamps, and table or French lamps — all these having burners on the principle above described. The former sort were, previous to the introduction of gas, very common in shops. The globe A (*fig.* 38.), which is sometimes made plain and sometimes embossed, as in the cut, screws off, when the oil is poured in at an opening in the lower part, which is afterwards closed by means of a slide attached to the stem B, and the globe, thus replenished, is inverted and screwed into the part C. When

the lamp is used, the stem B is raised a little, and the oil is suffered to flow through the intermediate tube

Fig. 38.

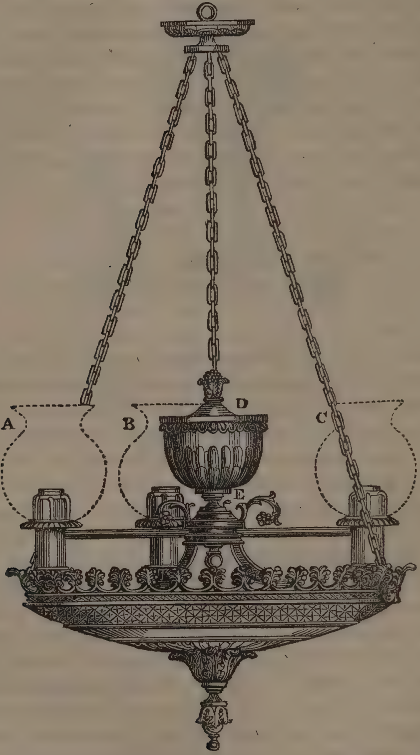


into the cistern D, only at the rate at which it is consumed by the burning of the wick. The peculiar form of the glass chimney E is admirably calculated to assist in the more complete combustion of the matter drawn up to the wick when impure oil is used, a desideratum originally in part secured by placing over the central tube, and in the midst of the flame, a circular metal plate, by means of which the ascending column of air was turned out of its perpendicular course, and thrown immediately into that part of the flame where the smoke is formed, and which by this ingenious contrivance is effectually consumed; this application, however, is not necessary, nor the form of much moment, when purified sperm oil is used. These lamps being usually made to move on a pivot at F, attached to the wall or other support, are very convenient in many situations, as being easily advanced over a desk or counter, and afterwards turned aside, when not in use.

Fig. 39. represents a suspension lamp with three Argand burners: the dotted lines, A, B, C, indicate the ground glass shades, which are usually placed over the

ordinary glass chimnies, to soften and harmonise the light. The reservoir D screws off, and is filled with

Fig. 39.



oil in the manner above described; and in like manner at E is the same sluice pin, by means of which the oil is suffered to flow through the lateral tubes to each of the three burners. These lamps, which are appropriate

for passages, halls, and public rooms, are manufactured by the artizans of London and Birmingham in every variety of material and style. In some of the more expensive articles, the beautiful productions of the glass-cutter's art are added, to give a higher degree of resplendency to the lamp. The greater proportion, however, are composed of gilt or lacquered brass, elegantly embossed and perforated, and often intermixed with bronzed ornaments, to give effect by contrast.

The most extensively useful article, however (portable vessels for the burning of gas being still a desideratum), is the upright table lamp (*fig.* 40.), and for

Fig. 40.

the original designs of which we are indebted to French taste. These lamps, like those above described, are

made of a great variety of patterns, and got up in every degree of plainness or splendour; but the principle and general form may be said to be the same in all; viz. within an hemispherical shade of ground glass, an Argand burner, on an upright shaft from fourteen to twenty-four inches high, with a solid pedestal. The wick is supplied with oil by means of cross tubes from a circular reservoir within the ornamental rim A B, upon which stands the glass shade C: the raised border at the bottom of the glass, and the brass coronet D, are now commonly omitted, as obstructing the light. The portability and elegant appearance of this lamp, together with the pleasing character of the light diffused by means of the shade, have led to a very extensive demand for it; accordingly, it is met with in almost every well-furnished house in the kingdom. A smaller variety, called the sinumbral lamp, has lately been introduced.

As already intimated, the lamp trade has suffered exceedingly by the introduction of gas, not only into shops, places of public worship, &c., but likewise into passages, halls, and even, in some instances, into dwelling houses. It has, however, happened, fortunately for the brass-worker, that the form rather than the material of the contrivance for dispensing light has undergone modification; while the weight of metal actually consumed has been very much increased by the change. For, while country mansions generally, to say nothing of many others, must still be largely indebted in their apparatus for artificial light to the brass lamp or candlestick maker, the extended use of gas has compelled tens of thousands of individuals to obtain standards or branches of that metal, who would otherwise have contented themselves with tin lamps or iron candlesticks. In the usual forms of our gas-light appendages we recognise the three distinguishing peculiarities of the lamps above described — the bracket, chandelier, and standard. The former surpasses the oil lamp in its capability of greater extension from the wall or other support, being composed of

two, three, or more tubes, carefully jointed, so that, when in use, it may either be retracted to the length of a single tube, or be brought out from two to three feet, as most convenient. Some of these branches, designed for churches and other public places, are very massive and elegant in their appearance, whether coloured in imitation of bronze, or made of lacquered brass.

The chandeliers for burning gas still more nearly resemble the suspended oil lamps in their general structure. In addition to the chains, however, which are mostly retained, as being ornamental, there is a tube descending from the ceiling, where it is held by a ball and socket joint to the centre of the lights, and communicating above with the main pipe: in some cases even this tube has been dispensed with; a hollow chain, invented by Mr. James Simpson, a Scotch advocate, who had a patent for it, having been used at once to suspend the lamp, and admit the gas. The standard lamps are generally straight or taper pillars of brass, more or less ornamented, and made to screw at the lower end into fixed sockets, communicating with the common service pipe.

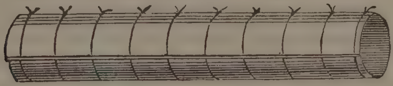
The ordinary burners are the simple jet, the batwing, and the Argand. The first consists of a single perforation, about the size of a common pin-hole, made in a small metallic knob or nipple; the second is a slit, cut with a saw in a knob of the same shape, and which causes the issuing flame to spread like a fan; this is the common gas burner used in the street lanthorns: it gives a considerable degree of illumination, with a moderate expenditure of gas, and its discovery is said to have been the result of accident. The third resembles, in general form and principle, the Argand burner of the oil lamp, except that, instead of the circular aperture for the cotton, the space is occupied by a small iron plate, in which is drilled a circle of minute holes, through which the gas issues in a tubular flame. Mr. Milne of Edinburgh is noted for the excellency of the Argand gas burner manufactured by him.

Very many Argand burners are now supplied with an improvement invented by the Rev. Mr. Kilby of Wakefield, and for which Messrs. Dixon of Walsall have a patent. The peculiarities of this burner are, first, the gas issues from a circle of perforations much more minute and numerous (from twelve to twenty-four), as well as more contiguous to each other than in the common burners, so that the flame is perfectly continuous, like that of an Argand oil lamp; and, secondly, from the construction of the air passage in the centre, a stream of air is impelled against the inside of the flame, and prevents it from contracting at the upper end, and assuming the form of a truncated cone, as it is often seen to do in the common Argands. Instead of being tinged with blue, as the flame of gas frequently is, it has from this ingenious burner a slightly yellowish cast, owing, as is supposed, to a more perfect degree of combustion taking place, while the saving has been shown by the meter to be from 20 to 30 per cent. in favour of this burner: but even this economy is a small matter to the consumer, as compared with the pleasantness of what every one who has seen this burner must admit to be its capability of yielding a rich, solid, and almost immoveable body of light, resembling that of pure olefiant gas.

Tubes of brass are used for an immense variety of purposes, particularly in the manufacture of telescopes and other optical as well as philosophical instruments, in the construction of several sorts of lamps, and very largely of late in the pendants and standards for gas lights. Tubes are made of sheet metal, which, for this purpose, is cut with shears into pieces of the length and breadth intended. If the tube is required to be two inches diameter inside, a narrow slip of the material is cut off, and bent close about a mandrel of that size, until the ends just meet; this, when straightened out, gives the breadth of the piece which is to form the tube. Such piece having been cut from the sheet — care being taken that the edges are exactly straight, and

the breadth uniform — it is next brightened by filing the surface about a quarter of an inch deep at the opposite edges on the same side. It is then placed upon a rounder of wood or iron, and, by means of a mallet, bent round until the edges come into contact, and which by hammering are made to lie very close and even — the brightened parts coming together in the inside, and presenting a clean surface for the reception of the solder. If, however, the tube were to be exposed to the fire for soldering in this state merely, especially if the metal should be thin, the heat would cause the suture so to open that it would be impossible to solder it: it requires, therefore, to be held together by hoops of small wire, placed at intervals of an inch apart, and twisted so as to bring and keep the edges of the metal in close contact, thus: —

Fig. 41.



The tube, thus prepared, is ready to be charged for soldering by the introduction of borax and spelter solder. For these purposes the borax (previously "burnt," or made to swell into a light friable mass by exposure to the fire on a metal plate) is triturated with water to the consistency of cream, in which state it is rubbed along the outside of the tube upon the seam, and laid in the inside all along the brightened part. This operation is performed by means of a small rod of iron, somewhat thicker than a flatted knitting pin, and which serves also to enable the workman, who must have a steady hand, to take up and convey into the tube a regular charge of spelter solder, which is placed in the borax upon the seam.

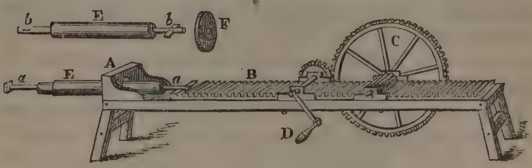
For the soldering of brass, green or blazing coals cannot be used; the best fire is composed of small black coke, which must be urged by the bellows until the

blast, by its action, clearly indicates the spot of the greatest intensity of heat. Over this fire the tube is to be held by a pair of light tongs, until the borax be somewhat dried or "risen;" this will be the case after bubbling awhile, during which it will mix up and detain the solder. The tube must now be heated along the opposite side, until it becomes slightly red hot; it must then be turned over, and the seam exposed to the hottest part of the fire, as nearly as may be, without touching the cokes; at a cherry red heat the borax will fall and melt, and presently the solder will follow; the tube, as the fusion proceeds, being drawn along, so as to expose every part of the line to the action of the heat. The tube must afterwards be laid carefully to cool, when a singular crepitation takes place, as the small scales and vitrified borax are detached in consequence of the contraction of the metal by cooling. Great care is required in the management of the foregoing operation: the bellows must be worked very gently, particularly after the tube becomes red hot, for the metal being exposed to the blast, is so nearly in a state of fusion when the solder melts, that it is often burnt through in consequence of not being removed at the exact moment when the soldering is complete: some sorts of brass, indeed, will stand a much greater degree of heat than others. The tube is also very liable to be broken, if allowed to touch the cokes during soldering, or if at all bent, or put into water while very hot.

On the removal of the wires, the tube is laid for half an hour in a pickle of sulphuric acid diluted with water, after which it is well washed and scoured with sand in clean water; on being dried it is ready for drawing. The drawing bench (*fig.* 42.), consists of a stout plank, bearing a front plate A, the rack B, a large cogwheel C, having on its axle a pinion acting on the rack; D is the handle affixed to another axle, with a pinion acting on the large wheel; E E are smooth steel maundrels, or triblets, very exactly turned, having shoulders near each end, and either knobs, as at *a*, or cottar-holes, as at *b*,

for connecting them with the near end of the rack: F is a whortle, or disc of steel, about an inch in thickness,

Fig. 42.



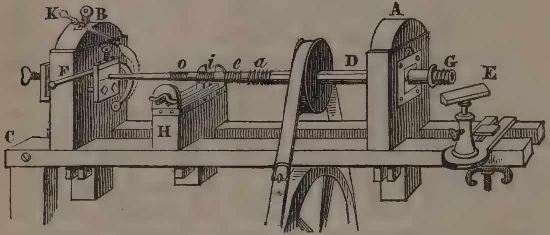
and having a hole turned in the middle, a little larger than the diameter of the maundrel.

The tube being pushed upon the maundrel, it is left to project at one end about a quarter of an inch beyond the shoulder, against which the projecting portion is beaten down with the edge of a hammer, so as to form a flange, and prevent the tube from slipping off over the maundrel in that direction: the neck of the maundrel, at the end just mentioned, is passed through the whortle, and fastened by means of the knob or cottar to the end of the rack, in the position indicated by E *a*. By turning the handle, and drawing onward the rack, the maundrel, with the tube upon it, is pulled forcibly through the whortle, which rests against the front plate; by this operation the tube is elongated, stiffened and brightened, in degrees proportioned to the amount of compression which is sustained between the maundrel and the whortle, grease being used upon all the articles for the purposes of lubricity. To strip the tube from the maundrel, a whortle turned to fit close to it, and called a "taker-off," is used, the maundrel being for this purpose attached by the other end to the rack. When the brass is very ductile, tubes may be reduced, by repeated lighting, pickling, and drawing, to a very thin body indeed, presenting at the same time a beautiful surface; but if the metal be bad, the tube will, if much drawn, fly open along the seam, or break into holes, or snap in the middle during the operation. To

prevent these evils, it is particularly requisite that the maundrel should be set, as at A, exactly in a line with the rack, that the whortle may operate equally on the tube: to secure, with the greater ease and certainty, this object, the drawing bench has been constructed in a vertical instead of a horizontal position, and having, instead of the rack, a flat chain, to which the maundrel being attached, in a great measure secures a straight pull.

The following is a representation of the brass-turner's lathe: A B (*fig.* 43.) are the puppets of wood, fastened

Fig. 43.

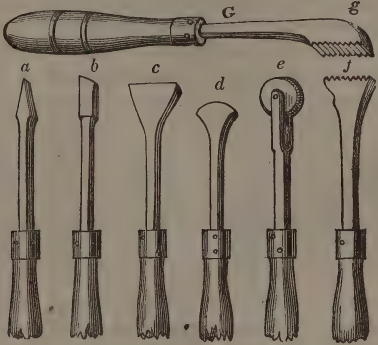


by means of wedges under the frame C: they may be made of cast iron upon a bed-piece screwed to the frame: D is the spindle, and E the rest; so far the parts are common to lathes in general. But in this engine the spindle, instead of being balanced upon a centre point at the small end, is finished with a knob, and rests in a collar, the frame of which projects about two inches from the near face of the hinder puppet, the intermediate space being occupied by the knob, and a small boss on a kick-up lever F, called the frog, against which it abuts, and is thus kept steady. The spindle is cut with screw threads of different sizes, *a, e, i, o*; the nose G contains on the outside a few turns of a large screw for the reception of wooden chucks, and in the inside it is tapped with a finer thread, for the insertion of brass chucks; the screw-puppet H has upon it a contrivance called a *director*, the use of which will presently

be explained. The chucks, which are screwed upon the bigger end of the spindle, for the turning of castings, are made of box-wood, holly, or crab tree.

The tools used by the brass-turner are the following (*fig.* 44.): *a*, point-chisel, used for cutting tubes into

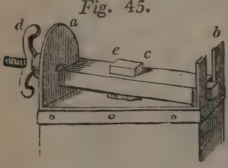
Fig. 44.



lengths, or making deep circular incisions; *b*, square-end, which, varied as it may be in shape, is for a great variety of turning; *c*, flat-edge, for turning straight surfaces; *d*, round-end, for hollows; *e*, knurling-tool, or corder for ornamenting raised parts, or roughing the finger-hold of screws; *f*, outside, and *g*, inside screw-tool. A casting being driven into a cavity in the end of a wood chuck, and made to "run true," as it is termed, by a few strokes with a hammer, a file is briefly applied to take off some of the roughness and outer-coating, after which the chisel *b* is used, until the article is reduced to the size and form intended; if it is to be screwed on the outside, the operation is as follows:—The workman throwing back the frog F, into the position of the dotted part K (*fig.* 43.); and turning the thumb-bit of the director screw on the puppet H, he works the spindle backwards and forwards a few turns, by means of a peculiar motion with his foot upon the

treadle. The space opened by the removal of the frog, allows the small end of the spindle to play horizontally, as the other end does, through its collars; and as the screw on the spindle at *i*, is pressed against by the rising of a bit of wood in the director, the motion at the nose is so exactly correspondent, that on the steady application of the screw-tool F, being of similar thread and pitch, a worm is cut upon the casting answerable in all respects thereto. It will at once be perceived how, with the other tool, an inside screw is cut by a similar operation. The side view of the director given in the margin (*fig.* 45.), will convey a more distinct idea of the manner in which this contrivance acts: the frame on the top of the puppet, is a piece of strong sheet iron beat up at the ends, *a b*; a square piece of iron *c*, is placed lengthways in this frame, having at one end a shoulder, fitted to move exactly up and down in the groove at *b*, the other end terminating in a screwed pin, which passes through a hole in the plate at *a*, and contains on the outside the eared-screw *d*. From this description it will easily be seen, that when the screw *d* is turned, it will, by drawing the angular end of the piece *c* against the inner side of the upright *a*, cause it to rise from the inclined position in which it is represented, so as to force the bit of wood *e* to bear against the under side of the spindle; and thus, by acting upon the screwed part, to cause the entire spindle to assume that vermicular motion before described. The moment the screw is cut upon the article on the engine nose, the eared screw *d* is turned back, the director falls into the inclined position represented, and allows the spindle to revolve freely as before. Some brass turners by long practice have attained the art of *running a screw*, as it is called, *i. e.* without using the director; and while the spindle is revolving as usual, they so apply, by a sliding motion, the tool as to

Fig. 45.

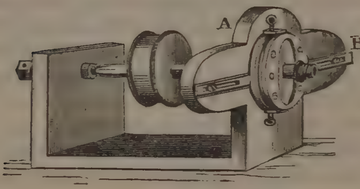


set out and finish the threads. Screws formed by this method, however they may serve for merely connecting pieces of metal together, are often waving and unfit for nicer purposes.

In fine-turning flat surfaces the tool *c* is used; the edge, which is ground somewhat sloping, being carefully whetted with oil on a fine stone. It has been found that the slightly passing along the edge a steel burnisher will make the chisel cut more smoothly; in fine work, however, the turning is rarely so perfect as not to require further getting up previously to lacquering: often, indeed, there is a roughness and *creasiness*, which are with difficulty removed by the application of sand and emery; the former is pounded ganister, used with a short soft stick dipped in water, followed by Trent sand and oil applied in a similar way: the latter, by attaching it with glue to strong paper.

Fig. 46. is the lathe for turning oval articles. The

Fig. 46.

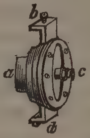


fixed parts are mostly the same as in the common lathe, except in the form of the front puppet A, which is cast with lateral projections, fitted with screws for the support of the director B. This appendage is a circular piece of cast iron, having arms perforated with openings in the direction of its diameter, so as to allow it to be fastened in the required position, by means of the above-mentioned screws, on the face of the puppet. From the surface of the circular part projects a ring or neck *f*, as shown in *fig.* 47.; the chuck, or sliding ap-

paratus, (*fig*. 48.), consists of three circular plates of considerable strength; to the first is attached the piece

Fig. 47.

Fig. 48.



a, having a screw inside adapted to the screw on the nose of the spindle of the lathe: the middle plate consists of two semicircular pieces, between which, and upon the surface of the first plate, the piece *b* is made to slide. To this slider is firmly attached the screwed nose *c*, to which is affixed the articles to be turned; the extremities *b d*, are bent so as to fit exactly upon the projection *f* (*fig*. 47.), their smooth and uniform motion being still farther secured by means of two screws. This slide is kept in its place in the chuck by the front plate, which, by means of an oblong opening, allows the neck attached to the slide to move backward and forward in the direction of the diameter of the chuck: the whole is kept firmly together by six screws, which pass through the plates.

When the apparatus is collectively fixed, as shown in *fig*. 46., the piece *a* screwed on the nose of the spindle, the bent ends embracing the neck *f*, and the director B fastened by means of the screws to the front puppet, so that the centre of the nose *c* shall be exactly coincident with that of the spindle, any article turned upon the lathe while in this state will be circular, exactly as if the apparatus were not present. It will be perceived, however, that if the director B be advanced in the direction of its diameter across the puppet, and fastened in that position by means of the screws passing through its perforated branches, the slider fitting close upon the projecting ring will be advanced also, and along with it the screwed nose or neck *c*. In this state, instead of

the centre of the nose *c* being coincident with that of the spindle, as before, the two centres *g h* (*fig.* 49.), are established, and any article turned upon the lathe while in this state will have, if operated upon so that its surface lie in the same plane with the spindle, every point of its circumference, or if figured on a face at right angles with the spindle, every point of its coincident lines, at equal distances from the nearest point of the line between the centres. To produce these effects, it will be perceived that, while the connection between the spindle and the chuck secures a rotatory motion, the arrangement of the slider allows the nose, and whatever article it may carry, to move through the lines above described.

Fig. 49.

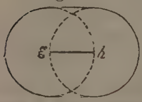


Fig. 50. represents the face of the near puppet of a

Fig. 50.

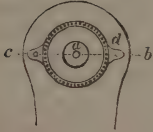
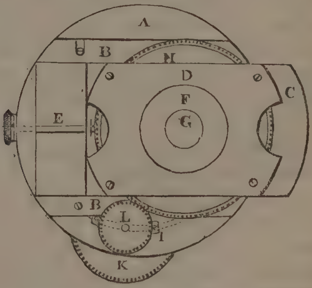


Fig. 51.



lathe, and *fig.* 51. a cycloidal chuck, for ornamental turning, originally described in the Mechanics' Magazine. In *fig.* 50., *a* is the spindle, *b* a brass cogwheel bolted to the head by the bolt *c*; the wheel having been previously soldered to a piece of thin iron with a projection on each side, *d*. In the face of the chuck (*fig.* 51.), A is a circular iron plate, three sixteenths of an inch thick,

carefully and accurately turned; B B are plates forming a groove for the principal sliding plate, C; D a cover for the principal wheel, of thin iron, supported by rings of brass beneath the four corner screws; F a piece of iron, carrying the screw G, upon which the work is to be fixed: this iron is turned with a pivot that goes through the large brass wheel H, to which it is firmly soldered, and this pivot turns in the principal sliding plate C; all the parts must be accurately turned and fitted. The principal wheel H contains ninety-six teeth, which are numbered upon it. If the head-stock wheel were removed, and a catch-spring added, so as to take into the teeth of the chuck, in this state, an eccentric motion might be communicated, and rounds of beautifully interlaced circles turned, in numbers corresponding to the size of the pinion used; and it might be made to answer for an oval chuck, by longitudinal perforations in the foundation plate, through which two lips might move upon the eccentric circle fixed to the head of the lathe. I, is a piece of steel, which has a corresponding one on the back of the chuck, to which it is strongly screwed, and through both of which a hole is drilled for the axis of the wheel K, which axis carries the driving wheel L. There is a concentric perforation in the plate of five sixteenths of an inch in breadth, which allows the two last-mentioned plates, with the wheels they carry, to follow the great wheel H, however far from the centre it may be set; K is a wheel on the back of the plate, cut with seventy-two teeth. It is twice the circumference of the one fixed upon the head of the lathe; which is, of course, cut with thirty-six teeth. When, therefore, the chuck is screwed into the nose of the spindle, the wheel K revolves *once* on the fixed wheel, while the spindle revolves *twice*. The small face wheel has twenty-four teeth, and is one fourth the diameter of the great wheel H; therefore that revolves *once*, while the spindle has turned *eight* times, and an accurate circle of eight cycloids will be traced. By having

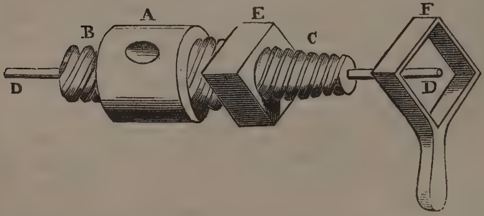
small driving wheels of different numbers, proper proportionals of ninety-six, the number of cycloids will be greater or less at pleasure, and may be cut nearer to or farther from the centre, one within another; and by taking off the small driver, and moving the great wheel forward or backward any number of cogs, the cycloids will intersect each other, with a beautiful and endless variety of forms. By making the small plate I sufficiently long to carry another small wheel upon a fixed pivot, all the patterns and cycloids are reversed. This chuck must be worked by a slow hand-motion: the movements being too complicated to admit the application of the foot, in giving revolution to the spindle, by means of a wheel and treadle, as in the common lathe, and even in the ordinary oval-turning engine.

The oval engine previously described may be used for the ornamental turning of surfaces on a plane at right angles to the spindle, especially if the chuck be so constructed that the work which is fixed upon it may be moved into various positions. For example, the simplest delineation of which the machine is capable will be the single elliptical line, executed by the application of a tool during one complete revolution of the spindle: this may be filled by concentric ellipses of diminishing diameter. If the work be then moved on its own axis, an eighth or a quarter of a circle, and concentric ellipses executed similar to the first series, these will cut each other, and form a handsome fret; or if the work be only moved a single degree after each operation of the tool, the lines will then be eccentric to each other in such a manner as to exhibit the beautiful appearance of some of the engine-turned watch-cases. If, instead of moving the work about its centre, it be advanced after every delineation in the line of its longer axis, the ellipses will be in the same degree eccentric to each other in that direction; or, if it be moved at right angles to that line, they will, on the contrary, be eccentric in the bearing of the shorter axis. Of course, if the con-

centric lines, instead of equidistant throughout, be turned in sets of three or four, with spaces between, the appearance of the work will be different, as it will be also by merely cutting the lines deeper at certain intervals. These remarks will show, that ornamental work of a pleasing character, and susceptible of considerable variety, may be executed by means of a comparatively cheap machine, possessing little complexity.

Brass-turners have often occasion to reduce various sizes of wire at the lathe for the purpose of making small-headed screws, studs, or other like matters. In the Repertory of Arts (vol. for 1806) may be found figures, and the description of a wire chuck, in which the wire to be turned is held by three common slit-head screws passing through a clumsy piece of brass; other contrivances, not better calculated for the purpose, have at different times been published. The following chuck will be found at once simple and convenient. A (*fig.* 52.)

Fig. 52.



represents a brass chuck, of which B is the part screwed to fit into the nose of the lathe spindle: C is a conical projection, say two inches in length, perforated exactly to receive the wire D D. This projecting piece is screwed outside, to receive the square nut E. It is afterwards cross-cut with a saw as far as the thicker part of the chuck. When the nut is loose upon the taper screw, the wire may be drawn out a little, or sufficiently

for the purpose required, after which, by screwing up the nut E by means of a spanner or grip F, the wire will be held fast enough to allow of the end being turned, and afterwards tapped, by an application of the screw plate: the screw may then be sawed off, and the screw being relaxed by means of the spanner, the wire is drawn forward a little, and the operations of turning, tapping, &c. repeated.

CHAP. XIV.

OPTICAL INSTRUMENTS.

EARLY DISCOVERY OF OPTICAL POWERS. — STATEMENT OF CLAIMS TO THE INVENTION OF THE TELESCOPE. — SUBSEQUENT ESTABLISHMENT IN THIS COUNTRY OF MANUFACTURES OF OPTICAL INSTRUMENTS. — SINGLE MICROSCOPES. — POCKET MICROSCOPE. — CULPEPPER'S MICROSCOPE. — JEWELLED MAGNIFIERS. — PRITCHARD'S JEWELLED MICROSCOPE. — PERSPECTIVE GLASSES. — OPERA GLASSES. — FLUID LENSES. — ACHROMATIC TELESCOPES. — DESCRIPTION OF DIFFERENT PARTS OF THE INSTRUMENT. — ASTRONOMICAL TELESCOPES. — REFLECTING TELESCOPES. — METALLIC SPECULA. — HERSCHEL'S FORTY FEET REFLECTOR.

Although it would be out of place in the present work to enter at all into details connected with the science of optics, the theory and phenomena of which, indeed, have been amply explained and elucidated in a volume devoted expressly to that subject by sir David Brewster *, yet, so largely does brass enter into the formation of the bodies and framework of most optical instruments, that it becomes desirable, in a treatise of the nature of that now before the reader, to take some notice of the manufacture of those parts which are composed of metal. It may not, however, be uninteresting to premise, that the history of both telescopes and microscopes is involved in considerable obscurity. The invention of the telescope has been referred to the thirteenth century, and it is said not only to have been perfectly well known to Roger Bacon, but to have been used in England long before the time of its alleged discovery on the Continent.† From documents preserved among the

* Cab. Cyc. (Optics), vol. xix.

† The invention of the telescope has been referred to a still earlier period. Father Mabillon mentions a manuscript he saw in an abbey in the diocese of Freisingen, wherein Ptolemy was represented, observing the

state archives in the Hague, it appears that, in October 1608, two individuals at least (and probably more) were actually in possession of the secret of making "instruments for seeing at a distance." An interesting article connected with this curious enquiry, and written by professor Moll of Utrecht, may be found in the earlier numbers of the Journal of the Royal Institution for 1831. This learned German, although he proves that Hans Lippershey, a spectacle maker of Middleburgh in Zealand, and Jacob Adriaansz, sometimes called Metius, of Alkmar in Holland, were both in possession of the art of making telescopes at the period above mentioned, remarks, that the latter, whatever the grounds of his formal pretension, certainly gave up his claim to the distinction of inventor, while there is little reason to believe that the former, who has commonly had credit for the invention, is really entitled to that distinction. He was certainly an ingenious artist; and it is probable, that either he or his son invented a compound microscope so early as about 1590.

Whoever was the inventor, it is generally admitted that this Hans Lippershey was the first actual manufacturer of the "spying glass." Moreover, there appears to be little doubt that the telescopes made by this optician for the states-general were binocular, although the invention of the instrument, afterwards so called, has been generally attributed to the capuchin friar Rheita, who describes it in one of the most singular books ever written. This conclusion results from the recorded fact, that their high mightinesses the Dutch legislators, to whom Lippershey presented a petition, praying for a patent, or the state patronage, accorded the latter, on the condition that the artist would make

stars with a tube, "like our modern perspective glasses." This manuscript is said to have been written in the beginning of the thirteenth century. Mabillon does not mention that the tube had glasses; neither indeed was that circumstance easily discoverable. "Perhaps such tubes were then used only to preserve and direct the sight, or to render it more distinct, by singling out the particular object looked at, and shutting out all the rays reflected from others, whose proximity might have rendered the image less precise." — *Phil. Trans.*, vol. xxi. p. 124.

the instrument convenient "for seeing with both eyes." This object he appears presently to have accomplished, after which he received for his first telescope the liberal consideration of 900 florins, or about 75*l.* sterling. The whole affair, and especially the readiness with which Lippershey furnished the states-general with the binoculos is, as Dr. Moll justly remarks, not only a proof of considerable ingenuity, but must tend to do away entirely with the notion that he was a low ignorant mechanic, guided by mere chance.

There has been a third claimant for the honour of the invention, also a spectacle maker of Middleburg: this is Zacharias Tansz, who has perhaps even more generally than Lippershey been considered as the original inventor. The information concerning this man is wholly derived from a book on the invention of telescopes, written by William Borel, who appears to have been very anxious about the matter; and being himself a native of Middleburgh, he had all the persons then living, who professed to know any thing on the subject, examined before the magistrates in 1655. Their depositions are given in Borel's book; but the originals of these depositions have not been found in the records of the town of Middleburg, although a very diligent search was made for them. In these documents the places and houses in which both Lippershey and Zacharias Tansz lived are frequently mentioned. These houses have since been taken down, and an open space now occupies the place where the telescope was invented.

Borel's account is in substance as follows:—"In 1591, the year in which he was born, a spectacle maker lived near his father's house at Middleburg; this man's name was Hans, and he had a son Zacharias, whom Borel knew intimately, they having been playfellows. This Hans, *i. e.* John, with his son Zacharias, as Borel often heard, invented the first microscope, which was presented to prince Maurice, and they afterwards obtained some reward. A similar microscope was afterwards offered by them to the archduke Albert of Austria. When Borel was ambassador in England, in 1619, he

saw that identical microscope in the possession of Cornelius Drebbel, of Alkmar, a man of much knowledge, and mathematician to king James. This microscope of Zacharias was not," continues Borel, "as they are made at present, with a short tube, but it was about eighteen inches long, and two inches in diameter, with a tube of gilt copper resting on two sculptured dolphins: under it was a disc or stage of ebony, on which the objects to be examined were placed. But long after, in 1610," adds our authority, "by dint of research, this Hans and Zacharias invented in Middleburg the long sideral telescopes, with which we gaze at the moon, the planets, stars, and heavenly bodies, of which a specimen was given to prince Maurice, who kept it secret, judging it useful in expeditions. However, as this admirable invention was rumoured about, and as curious men were talking about it in Holland and elsewhere, a stranger came from Holland to Middleburg to enquire into this matter, and asking for a spectacle maker, he was shown, by mistake, into the shop of John Laprey. He spoke with him about the secret of the telescope. Laprey, being an ingenious man, and a close observer, heard attentively what the stranger said, and thus, with laudable industry and care, became the second inventor of the long telescope, which he made to the satisfaction of the stranger."

Nearly contemporaneous with the date of the above inventions was the era of the construction of a telescope by Galileo, and with which that celebrated astronomer discovered the satellites of Jupiter. His own account of the matter is contained in a letter dated March, 1610, in which he says, "It is about ten months ago that it came to our ears, that a glass (*un occhiale, perspicillum*) had been worked by a Belgian, by the help of which visible objects, though at a great distance from the eye of the observer, may be seen distinctly: and some experiments were related of the admirable effects of this instrument, which some believed, and others not. A few days afterwards the same was confirmed by letters

of a noble Frenchman, Jacob de Badorere, from Paris, all which occasioned me to apply myself wholly to enquire into the cause of this, and to think on the means by which the invention of a similar instrument might be brought about; in which I succeeded in a short time, assisted by the doctrine of refraction; and I first procured a leaden tube, at the end of which I adapted spectacle glasses (*vitrea perspicilla*), both plane on one side, the one convex on the other side, the second concave. Bringing the eyes near the concave glass, I saw the objects large, and near enough; they appeared three times nearer, and nine times larger, than if seen with the naked eye. Afterwards, I made another instrument, which made objects appear sixty times larger. Finally, sparing neither industry nor expense, I succeeded so far as to make an instrument of such excellence as to make the objects seen through it appear a thousand times larger, and more than thirty times nearer, than if seen with the natural power of the eye." Whatever Galileo may have meant by these terms, it must not be supported that his telescope had really what opticians call a power of 1000 times, though some persons appear to have fallen into this mistake. In a Galilean telescope, the focal length of the object glass cannot go beyond a certain extent, without narrowing the field too much. The eye glass cannot be made very deep without making it too thin in the centre. Even at present, it would, perhaps, be difficult to make Galilean telescopes of greater power than 32, which is indeed that which Galileo himself obtained.

During the century which followed the invention of telescopes, a proper share of the attention of the philosophic world was directed to the improvement of the instrument. It is, however, little more than within about fifty years since, that the progress of scientific investigation, together with the cheapness of brass, as well as economical and improved methods of fabrication, laid the foundation in this country of an extensive trade in telescopes and microscopes of all descriptions, along with a vast variety of apparatus for philosophical pur-

poses, in which brass is the principal material. Thus, while the more opulent patrons of the science gratified their taste by the purchase of unique instruments at any price from the first makers, the curiosity, and indeed the convenience of the public in general, created a considerable demand, to meet which, ingenious workmen were set to produce, according to established data, instruments, the theory of which the manufacturer sometimes little understood, and still seldomer extended beyond the articles so successfully copied, in vast quantities for the metropolitan houses, and presently, for more direct sale on their own accounts. Not only in London, but in Birmingham, and particularly in Sheffield, the business of the optician has been carried on with success; at the latter place there existed, between thirty and forty years since, the largest optical manufactory in the world; so extensive, indeed, were the operations, that the power of the steam-engine was applied to the grinding of glasses, a process which, as there conducted, is one of the most interesting that a stranger can witness. There are, at present, some extensive works of this description in the last-named town; and there, as well as in other places, instruments, at the sight of which some of the old scientific investigators of this and other countries would have felt no little surprise, are daily produced in a beautiful style at exceedingly low prices. The combination of neatness, efficiency, and cheapness has led to the almost universal possession of some one or more articles of this class.

The simplest form of an optical instrument is the single microscope, consisting, as the name imports, of one lens only, in contradistinction to the compound instrument, in which there are more glasses. If, however, the lens be large, like that used by the watchmaker, it is generally, including the rim, whether of wood, horn, or metal, simply called a magnifier, or sometimes, according to the purpose intended, a quizzing glass. The description of lens last alluded to, whether concave or convex, whether made of crystal or some artificial

vitreous composition, is commonly identical with those mounted as spectacles, — the latter undoubtedly the most ancient, not to say the most useful, application of the optician's art. An exceedingly useful variety of the single microscope, and of which thousands are sold in a year, is that designated, from its application, a "cloth prover." It consists of a good lens of about $1\frac{1}{4}$ inch focal length, neatly fitted into the upper end of a little brass body, at the opposite end of which is a plate having a round, or more commonly a square perforation, exactly an inch, or some fractional part of an inch in diameter, the whole made to shut up like a small box for the pocket. The usefulness of this instrument, in enabling a person exactly to count in a given area the number of threads forming the warp and weft of almost any sort of woven fabric, and thus to estimate its comparative fineness, must be very obvious; and, accordingly, woollen and linen provers are extensively manufactured. Of course, this little contrivance is also useful as a microscope for a variety of purposes, especially in the examination of minute parts in the structure of flowers; though there are larger lenses, more appropriately mounted, for the use of gardeners and botanists.

Fig. 53.

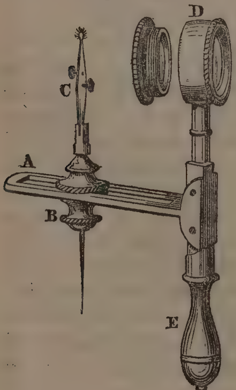
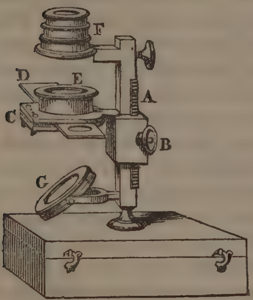


Fig. 53. represents a small jointed microscope, of a neat construction, and which, as it admits of being folded together and placed in a morocco case about the size of one's finger, is very convenient for ladies. A is the frame, having a longitudinal perforation, in which slides a small screwed button B, intended to fix nearer to or farther from the eye; the nippers C detaining the insect or other object under inspection. This last-named contrivance is common to several other microscopes,

and consists of two bits of watch spring, each about $\frac{3}{4}$ths of an inch in length, and so soldered into the brass head of a needle as to form a pair of tweezers, opening by the pressure of two small studs: instead of the nippers, the needle may be used for impaling any minute object. D is the eye-bit, with two screwed cells, one shown as detached, containing lenses. E is a neat handle of ivory fitted into a brass socket, which, as well as the stem of the eye-bit, is pinned into the frame at the thicker end, and upon which, when the needle and nippers are removed, they shut closely down. There are several varieties of this instrument, differing chiefly in size, and perhaps a little in their subordinate parts.

The annexed engraving represents a very elegant and powerful little instrument of the compound class, commonly known as the pocket microscope. It stands about four inches high, and, when not in use, may be enclosed in the box which serves it for a pedestal. A (*fig.* 54.) is a fine smooth rack, upon which slides a box containing a pinion, with its head B. This box carries the double-plated table C, between the two parts of which is passed the ivory slider D, containing the objects for examination placed between very thin laminæ of talc fitted into the little cells of the slider. E is a small brass box, glazed so as to enclose any small living insect: when it is removed, the cavity of the upper plate is adapted to receive a concave glass, with a drop of vinegar, or other fluid, to show the presence of animalculæ. This microscope has either a compound eyepiece, or three different magnifying powers, which may be used together or separately: the cells containing the lenses are screwed into a small brass limb at F. At

Fig. 54.

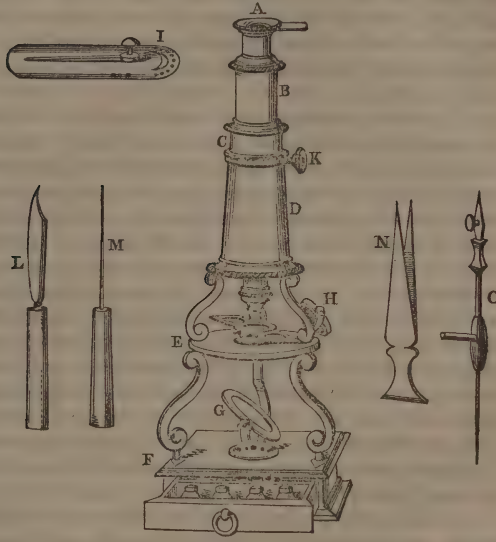


the lower end of the rack is a mirror G, which, being placed at the proper angle for reflection, strongly illuminates the object under examination. It will be obvious that the rack and pinion contrivance is for the purpose of adjusting, to the greatest nicety, the distance between the lens and the object, so as to suit the eye, and also to adapt the instrument to the focus of the magnifiers, either when used separately or together, as represented in the cut. The instrument is furnished with needle and nippers, a small knife, a mounted needle, and a pair of tweezers, similar to those described in connection with the next article, for the conveniency of dissecting any object which it may be desirable so to treat. There are other and larger microscopes, which are regulated by means of rack and pinion work, which, as used alone, is perhaps, on the whole, one of the best contrivances for adjusting the magnifiers to the eye and to the object. In some cases, however, these objects are obtained with greater precision by means of a screw; and frequently the adjustment is made to depend merely upon the sliding by hand of the moveable part of the instrument. This is the case in the trunk microscope, and also in the tubular microscope, called, after the old London optician, Martin's: each of these, having three magnifiers, is a useful instrument, though less readily adapted to its purpose than if it were moved by a rack or screw.

An elegant and powerful instrument, called the pyramidal, or Culpepper's microscope, was at one time in considerable demand: it stands from twelve to fifteen inches high; has four magnifiers, which vary the power of the instrument; and the whole is fitted into a neat mahogany box. *Fig.* 55. shows this microscope, as set out for use: A is the slide head, turned concave for the reception of the eye; B the eye tube, containing two powerful lenses; C the slide tube, by which the instrument is adjusted; it moves smoothly in a spring through the body D, having in some cases a rack and pinion movement at K, which is a great improvement upon the old instrument, the tube of which, not always being re-

gulated by a rack or vertical screw, cannot be raised or lowered with so much steadiness and certainty, as when either of these conveniences is attached. E is a circular brass table, supported by three crooked pil-

Fig. 55.



lars, which are screwed upon the box F, and attached at top to the base of the conical body D. In the middle of this plate, there is an apparatus for the reception of ivory sliders, such as those above described, a number of which, charged with appropriate objects, always accompany the microscope. G is a mirror, adapted to reflect light upon any transparent object under examination; and H is an illuminator, auxiliary to the same design: I is a contrivance called the frog-plate; its purpose being to detain that animal by means of a silk bag, which can be attached to the plate, while the circulation,

pulsation, and other phenomena are witnessed, by fixing one of the limbs across the crescent-shaped perforation in the end of the plate, which is itself attached to the table of the microscope by the insertion of the stud: L is a small knife, M a needle, and N a pair of tweezers for dissecting objects; O the needle and nippers. The mahogany box F, besides being the receptacle of the knife, tweezers, slides, frog-plate, &c., contains the magnifiers, marked, according to their respective powers, 1, 2, 3, 4.

It would be improper wholly to pass over without notice a recent discovery, which has tended, in the opinion of scientific individuals, very much to improve the efficiency of the microscope. In 1811, Dr. Brewster pointed out the valuable properties of the diamond for optical purposes; and actually caused lenses of garnet and ruby to be ground: these and other gems combine desiderata of very great importance in a perfect lens, viz. a high refractive with a low dispersive power. In the beginning of 1824, Dr. Goring and Mr. Pritchard, optician, entered upon the arduous experiment of attempting to grind diamond lenses. The promptness with which the work was executed was only surpassed by the gratification experienced, when, at the latter end of the same year, the ingenious artist was rewarded by looking through the first magnifier of adamant that was probably ever produced. It would be out of place here to describe the difficulties which had to be encountered and overcome in the working of so precious, so peculiar, and at the same time so refractory a substance: these matters are before the public in the treatises of the individuals above named. According to Mr. Pritchard, the first and most obvious advantage of the jewelled microscopes is the superior amplification obtained with shallow curves, arising from the great refractive power of the precious stones, as before mentioned. Another and no less important object is attained by lenses of gem, viz. a vast increase of magnifying power, arising from their enormous refraction.

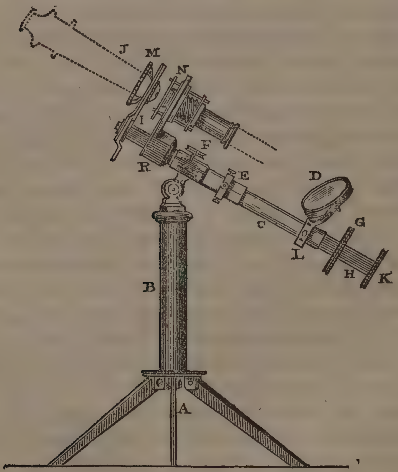
In addition to these qualities, may be mentioned their superior cohesion, which enables us to burnish them into small circular discs of metal, which object cannot be so conveniently accomplished with glass, thereby permitting them to be taken out of their mounting and cleaned, without any risk of losing, or danger of scratching them.

The subjoined description, with the figure following, of an elegant microscope for jewel lenses, are from Mr. Pritchard's "Microscopic Cabinet." This ingenious writer, after noticing the most usual contrivances for adjusting the distances of the magnifiers from the object, says, "The advantage of the rack and pinion-adjustment is the speed by which the object or magnifier can traverse a long space, — a property that is highly useful when the magnifying power of the microscope is required to be augmented or decreased; and when accurately made, with a large milled head, is very effective for general purposes. This method has, however, mostly yielded to the screw adjustment, when high powers are used, on account of the delicate and accurate motion required for them. Again, while the latter is preferred for such purposes, it is too tedious in its operations for low powers, where speed is necessary. Hence, both these methods have occasionally been combined, and thus the desired object has been effected; but, unfortunately, this has added much to the complexity and expense of the instrument. Independent of the defect alluded to in each of these methods, there is another, seldom overcome, except by very accurate workmanship, and even then a little wear soon exhibits it; it is techically termed the *drop* or *back lash*, and occurs when the motion is changed; the head of the screw or pinion turns round a certain portion before its operation commences. Hence, when a very minute change is wanted, it cannot be effected with precision.

"In the plan here adopted these defects are entirely obviated, while the advantages of each of the methods

above referred to are preserved. It consists in employing a fine screw, kept up to its bearing by means of a steel spiral spring, for the delicate adjustment, while the whole, being connected with a tube sliding within the stem of the microscope, allows of a coarse adjustment: the friction between the tubes exceeds that of the triangular bar, and holds them stationary, while the fine adjustment is effected by the screw; so that either or both adjustments may be made without the assistance of a pinching screw, or throwing it in or out of gear, as will appear from the drawing and following description." *Fig.* 56. shows the microscope set up for view-

Fig. 56.



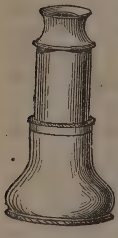
ing transparent bodies by reflected light in an inclined position, but any other position or mode of illumination may be used in observing them. When the instrument is laid in its case, the legs A of the tripod stand are re-

versed, and being brought close to the pillar B, the stem of the microscope C is placed parallel to the latter, and thus occupies very little space. In setting it up for use, the stem C being first raised, the legs are removed, and screwed tight on the pillar, as shown in the figure. On the tubular stem C slide the sockets L E, the former of which carries the reflector, as shown at D; the latter carries the condenser, which in the figure is omitted; it consists, however, of a single lens, mounted exactly in the same manner as the mirror D. Each of these sockets can be turned about in any direction, or slid up and down the stem, without a tightening screw, having sufficient spring and friction on it to remain stationary in any position without clamping. The microscope is connected with the stand by the clip F: it can be turned about in any position, and is fixed by its pinching screw, which should be securely tightened before the microscope is used. Within the stem C slides a tube H, connected by a tube passing through it to the triangular tube and arm I. By sliding the tube H up or down, the magnifier M in the arm I is adjusted to objects situated at N, while the milled head K revolves, and affords a delicate and final adjustment. The stage containing the slide holder N, fits into the triangular box at the termination of the stem, by means of two pins, and can be removed altogether. The instrument may be converted into a compound microscope, by the addition of an eye tube containing two more lenses, and screwed into the magnifier, as represented by the dotted lines at J.

There are two other classes of microscopes justly astonishing by their powers, but constructed on principles different from the above, and which need only be named here: first, those which exhibit a magnified *image* of an object, and have been called engiscopes by Dr. Goring; and, secondly, the solar microscope, with the amazing performances of which the public is occasionally entertained, and the effect of which depends upon principles similar to those of the magic lantern.

The simplest forms of the telescope, are those known to the trade as "perspective glasses," and of which immense quantities are manufactured by country opticians at a cheap rate; their magnifying power is from 3 to 6, so that they are of little value, though they serve as pleasing toys for young people. These "prospects" are fitted with a small concave glass next the eye, and a convex one at the contrary end, precisely according to the construction of Galileo's telescope, the only difference between these instruments and the common opera glass being, that the latter has usually a much wider field of view, and is also got up in a more expensive style. Twenty years ago, the demand for all sorts of opera glasses constituted no inconsiderable proportion of the business of the optician; and the writer happens to know that, about that time, one house had not less than 1000*l.* worth of the articles in stock. Besides the great quantities, of which the draw tubes, mountings, and various connecting parts were composed entirely of brass, many were made of plated and gilt metal, of silver, and some of a still more precious material. The bodies or outsides were of equally diversified composition, as varnished wood, tortoise-shell, *papier-mâché*, but, perhaps, most commonly of ivory, or japanned metal; the last-named style admitting of many elegant decorations by gilding or otherwise.

Fig. 57.



Of the annexed cuts, *fig.* 57. represents the bell opera, which has not only an elegant appearance, but, on account of its shape, admits of a wide object glass. *Fig.* 58. is a many-draw opera: the shortness of the several tubes allows this instrument to shut up into a small space: they are sometimes made with as many as ten draws, a great object with the manufacturer being, that the springs shall work smoothly, and at the same time fit the tubes so nicely, that the instrument shall not readily bend

Fig. 58.

when fully drawn out. The "side opera" (*fig.* 59.) has no object glass, but instead thereof a flat mirror occupying the lower part of the body, and inclined at an angle of 45° to the eye-glass; so that, by means of the perforation at A, any person or object may be noticed by the user of the opera glass, while the instrument is apparently directed to quite a different quarter. The French have for some time past enjoyed the principal part of the trade in opera glasses; their ingenuity has taught them to combine lightness, elegance, and cheapness in a surprising degree; so that what remains of the home trade in these articles is almost confined to the more expensive and highly-finished sorts. The manufacture of that singularly ingenious optical toy the kaleidoscope, invented by Dr. Brewster, underwent a still more sudden vicissitude. In 1818, the numbers of this instrument manufactured by Mr. Carpenter of Birmingham, and Mr. Cutts, a respectable Sheffield optical instrument maker, were incredibly great: the rage, however, for the possession of the instrument subsided almost at once, and, of the thousands of the articles then dispersed over the country, it is now scarcely possible to meet with one, to show to a child that has become twelve years of age since that period the nature of the plaything that so greatly entertained its elder brothers and sisters.

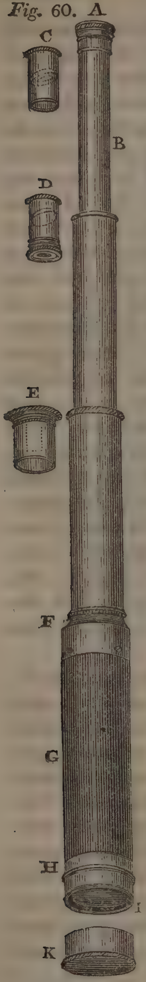
Fig. 59.

There is an extensive variety of telescopes manufactured, containing from four to six glasses, and which, as to price and magnifying power, hold a sort of middle place between those above described and the more perfect achromatic instruments. They are got up of various lengths and diameters, and some of them are

by no means despicable for ordinary purposes: indeed, until about the middle of the last century, they belonged to the first class of telescopes. About the year 1757, Mr. Dollond, an eminent optician in London, published the important discovery that different transparent substances have different dispersive powers; that the same dispersion may be produced or corrected by a less refraction of the mean rays in one case than in the other; and that refraction might thus be produced without colour or, in other words, nearly free from that prismatic fringe which appears to surround the field of view in any indifferent telescope, or even in a good instrument in which the internal apertures are too wide or improperly adjusted. The application of this principle led to the use of concave lenses of flint glass in conjunction with convex ones of crown glass, in the composition of what have ever since been called, from this colourless property, achromatic object glasses, and with which all the better sorts of refracting telescopes continue to be manufactured. Several attempts have at various times been made, particularly by the late Dr. Blair of Edinburgh, and more recently by professor Barlow, and subsequently by his son, still farther to perfect the achromatic object glass by the use of different enclosed fluids.

Achromatic telescopes are made of various lengths; commonly, however, from 14 inches to 4 or 5 feet, and of a proportionate diameter: they have one, two, three, or more tubes, according to the taste of the manufacturer or purchaser. The smallest of these instruments will, if a good one, show the satellites of Jupiter. The annexed cut (*fig.* 60.) represents one of these telescopes, showing, at the same time, the interior parts detached: the description applies equally to the several parts of each of the instruments above named, the chief difference being in the size. The telescope represented in the cut consists of three draws, is 28 inches long, when

Fig. 60.



the tubes are drawn out: it is very portable, and adapted to the pocket, being about 9 inches in length when shut. The head A is screwed upon the near end of the first tube B; the sight hole in its face is nicely adapted to the eye: in some of the larger telescopes the head is hollowed out in front, to admit the eye still more closely, as it desirable that no light should be admitted by this aperture. When the instrument is not in use, this hole is closed, either by a straight slide, or by a slightly different cover, called, from its form, a kidney-bit; the former contrivance, however, is by much the more common. Immediately within the eye-tube is pushed the short pipe C, having at each end a cell for a glass, and between them a stop or diaphram to regulate the admission of light: at the opposite end of the eye-tube is screwed another short pipe D, having, like the former, a cell to hold a lens at each end, and a stop, with a very small hole, between them. Each of the three draws is made to slide smoothly through what is called a spring, E, consisting of a short bit of tube, slit at opposite sides, and soldered into a ring which screws into the near end of each draw tube, and into the front mounting at F. Upon the end of each draw is soldered a small ring called a check, and which, by coming into contact with the spring, when the telescope is fully extended, prevents the tubes from actually coming out of each other, as is the case with those cheap old-fashioned telescopes, with paper tubes and horn or wooden mounting, which we

occasionally meet with. G is the body-tube, generally made of mahogany or sycamore wood varnished, but sometimes of metal. It is fitted with two brass mountings F H; into the former of which, as before stated, is screwed the large spring, and into the other the cell I, containing the compound object glass. This end is closed with a cap K, when the instrument is not in use. In some cases, this cap is fitted with a slide, or superseded by a slide head.

There is a class of achromatic telescopes, differing from the above chiefly in the greater width of their tubes: they are constructed purposely for ships, and for looking at objects at sea, having an extensive field of view; on which account, and also as possessing considerable brightness, they may be used even in hazy weather, as well as for nocturnal observations; hence, they have long been known as the "Day and Night" telescopes. They have either one or more draws, and are occasionally made with a tube to slide from the body over the mounting at the wide end, and which, when drawn out, serves to screeen the sun or rain from the object glass.

In each of the above-mentioned description of telescopes, the focal adjustment is not only dependent altogether upon the uncertain method of pushing in and pulling out the eye-tube with the hand, until the proper distance of the glass is ascertained by the greater distinctness of the object, viewed; but that being done, the telescope itself must be held in the hand, unless it can be steadied by resting it upon some convenient elevation which may happen to be near, or by placing it upon some such rest altogether. To produce the requisite degree of precision in the former particular, a rack and pinion motion has been applied to the eye-tube; while the latter inconvenience has been remedied by the attachment to the instrument of a suitable stand. For any of the telescopes above described, a stand similar to that attached to the microscope shown in *fig.* 56. is very convenient, the clip F being placed upon

that tube or part of the instrument nearest the centre of gravity.

Fig. 61.

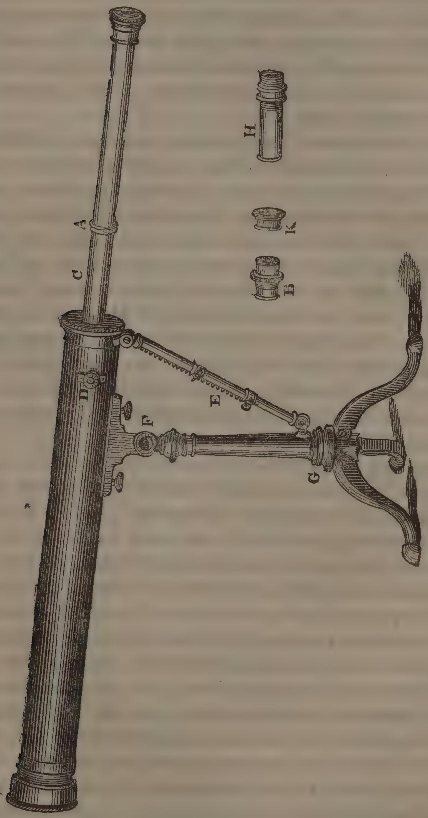


Fig. 61. represents a four-feet achromatic telescope, mounted on a saddle stand. The optical construction

of this instrument does not particularly differ from those already described, except that the ordinary eye-tube screws off at A, where may then be affixed one considerably shorter, H, or the small astronomical eye-piece B, containing a combination of lenses more particularly adapted for celestial observations, and by which the magnifying power is raised from 55 to 390 times: its outer end is screwed, to receive the head K, which contains a flat glass of a deep yellow colour, for looking at the sun. Upon that part of the tube C which is within the body, is affixed a finely toothed rack, which is actuated by a pinion through the knob D, and by means of which the focal relations of the glasses may be very easily and accurately adjusted. E is an arrangement of tubes sliding into one another, and which, by means of rack and pinion work, serves to regulate the bearing of the telescope towards any object with great steadiness and accuracy: this vertical motion is allowed by the joint at F, while an exact and smooth horizontal movement of the whole instrument is afforded, in consequence of the nice fitting of a piece at the bottom of the pillar, which passes through the pediment of the stand at G.

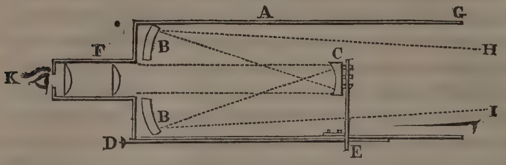
The making of these instruments involves no operation which is not generally described in the previous chapter on brass tubes and turning, unless it be the pinion work; and the management of this is not difficult to an ingenious workman. The pinions may be obtained of the clock-maker, either rough-cut, as they come from the engine, or smooth-filed, ready for use: when wanted very small, they may be easily turned out of pinion wire, as is done in making the pinions for all sorts of watch-work. The rack may be cut by means of a finely toothed saw, or serrated steel blade, very straight, and of the proper thickness for the leaf. Having prepared the rack, and carefully measured, cut, and filed up one tooth, so as exactly to suit the pinion, fasten on one side of the saw a strip of brass exactly the

thickness of the tooth, and the lower face of which may lie parallel with the line of saw teeth, but just so much above them as is required for the depth of the teeth of the rack: then rivet upon this strip of brass another saw exactly similar to the first, but whose teeth shall only just begin to act upon the rack, when the first-mentioned blade has cut to its proper depth. By using this tool at an exactly right angle with the length of the rack, one tooth may be cut down to the depth determined by the brass gauge, while another, the next in order, will be set out, and must be cut down in its turn, and so on until the rack is cut throughout its length. The teeth will then only require to be dressed up with a feather-edge smooth file; after which, if intended to be exposed, it may be got up by brushing with emery, sand, and rotten-stone. The writer has frequently cut racks both for telescopes and microscopes with a single saw, advancing, after each incision, a small gauge from one tooth to another, as a guide for the instrument.

In the reflecting telescope, of which the side opera glass previously described may be said to be a miniature representation, metallic specula are used instead of the achromatic object glass: these instruments, as they differ somewhat in their construction, are generally called after the names of those who first suggested or applied their respective principles, Newtonian, Gregorian, and Cassegrainian. According to Dr. Brewster, Mr. James Gregory was the first person who described this instrument, though it does not appear that he ever actually constructed one; the honour of having done this with his own hands belongs to the illustrious Newton. In sir Isaac's telescope, the magnifying power is applied to the image of an object reflected from a concave mirror, upon a plane one inclined thereto, at a certain angle, within the body. The reflector of Gregory contains two spherical specula, a greater and a smaller, whose axes are coincident, and the concave surfaces of which are turned toward each other. The annexed

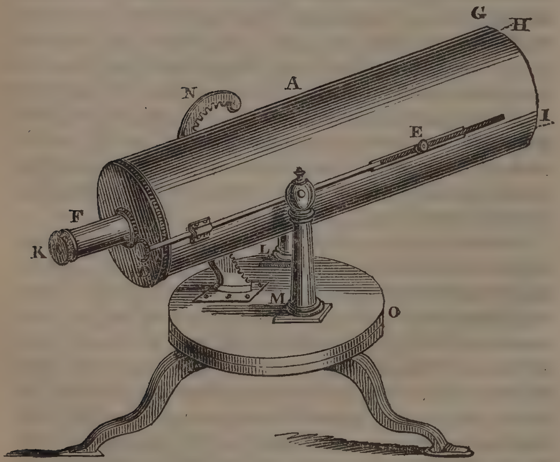
diagram (*fig.* 62.) exhibits a section of a Gregorian

Fig. 62.



telescope, and the following cut (*fig.* 63.) is taken from

Fig. 63.



an instrument of the same construction, of the price of about ten guineas, and adapted to the parlour table: the letters of reference are the same in both figures. A is the body, or large tube, about 15 inches in length, and $3\frac{1}{2}$ inches wide: B B the large speculum, perforated in the middle, its concave polished surface toward the open end of the instrument, and its back to the eye-

tube F; C a small concave speculum, which can be moved nearer to or farther from the large one, by means of the screwed wire D, the arm of the small mirror being for this purpose fitted to a slider in the groove E. An eye-piece F, consisting of two convex lenses, placed at a distance equal to half the sum of their focal lengths, is screwed into the near end of the large tube, immediately behind the great speculum. The telescope is left completely open at the end G, and the image of a distant object entering in the direction of the dotted lines H I, is first received upon the large speculum, and thence reflected upon the small one, where it is beheld through the eye-tube, the eye of the observer being placed at K. These instruments are variously mounted, according to their size, and the degree of accuracy aimed at by the maker: in the one above represented, L M are two brass pillars, between which the large tube is poised upon side pivots, the degree of inclination being regulated by means of a pinion acting on the sector-rack N. The whole has a horizontal motion, depending upon the arrangement of the two plates composing the circular piece O.

Cassegrain's telescope is very similar to the Gregorian, except that the smaller reflector is convex. The object of this alteration is, that the abberation of the lateral rays produced by the first reflection, may be, in some measure, corrected, whereas, in the Gregorian, the aberrations produced by the two reflectors being in the same direction, the second reflection increases the fault of the first. In each of these telescopes, as will be perceived from the description, the optical effect is actually made to depend upon the form and adjustment of polished metallic discs, while the magnifying power of the eye-tube is directed to an image of the object, and not, as in the Galilean and other glasses, to the object itself.

In the construction of reflecting telescopes, the utmost degree of nicety is required in the composition, curvature, and polishing of specula, and various formulæ have at different times been published with reference to

these points. The following ingredients, originally announced in the Nautical Almanac for 1787, are said by recent authorities to form a compound, possessing in a high degree the requisite qualities of hardness, whiteness, and consequent highly reflective property; viz. copper 32 parts; tin 15; brass 1; silver 1; arsenic 1. In addition to great specific gravity and whiteness, as being essential to the reflecting power of a speculum, must be considered the nature and perfection of the curvature communicated. Instead of working and polishing mirrors for telescopic purposes, so as to present exactly spherical surfaces, it has been proposed to adopt curves generated by the revolution of the ellipse, parabola, or hyperbola, in order to lessen the aberration or correct the unequal refrangibility of the rays of light. The advantages or otherwise of these curves is a question, the discussion of which does not come at all within the province of the ordinary manufacturer; it may be sufficient here to mention, that whatever may be the theoretical or even practical advantages contended for, the difficulty of accurately grinding surfaces depending upon such a nice deviation from the spherical is very great indeed. For an account of the *modus operandi* pertaining to the casting, grinding, and polishing of metallic specula, the reader will find an interesting article, by Mr. Potter, in Brewster's "Edinburgh Journal of Science," January 1831; he may also refer to the original paper of Dr. Mudge, published in the Philosophical Transactions for 1777, or Mr. Edwards's Essay, republished in the Nautical Almanac for 1787; but, above all, Mr. Potter advises the amateur that he should peruse sir Isaac Newton's account, given in his Optics, of the method he followed in the first reflecting telescopes: he will there find the process of polishing described, almost the same as practised at present, in a manner equally concise, instructive, and complete.

The most celebrated name, as a maker of reflecting telescopes, is that of Short, whose prices run from 14 to 800 guineas, the instruments being from 1 to 12 feet

focal length. The fine Gregorians executed by this individual were so superior, that the Newtonian form of the instrument fell into disuse. It was revived, however, says sir David Brewster, who has himself proposed some improvements, by the late sir William Herschel, whose labours form the most brilliant epoch in optical science. With an ardour never before exhibited, he constructed no fewer than 200 seven feet Newtonian reflectors, 150 ten feet, and 80 twenty feet in focal length. But his zeal did not stop here. Under the munificent patronage of George III., he began, in 1785, to construct a telescope 40 feet long, and on the 27th of August, 1789, the day on which it was completed, he discovered with it the sixth satellite of Saturn. The great speculum had a diameter of 49½ inches, but its concave surface was only 48 inches. Its thickness is about 3½ inches, and its weight, when cast, was 2118 lbs. Its focal length is 40 feet, and the sheet iron tube which contained it was 39 feet 6 inches, and its width 4 feet 10 inches. By using small convex lenses, Dr. Herschel was enabled to apply a power of 6450 to the fixed stars, but a very much lower power was in general used. In this telescope, the observer sat at the mouth of the tube, and observed by what is called the *front view*, with his back to the object, without using a plane speculum, the eye-lens being applied directly to magnify the image formed by the great speculum. In order to prevent the head, &c. from obstructing too much of the incident light, the image was formed out of the axis of the speculum, and must, therefore, have been slightly distorted. As the frame of this instrument was exposed to the weather, it was greatly decayed. It was therefore taken down, and another telescope of 20 feet focus, with a speculum 18 inches in diameter, was erected in its place, in 1822, by J. F. W. Herschel, esq. with which many important observations have been made.

CHAP. XV.

CLOCKS AND WATCHES.

GREAT VALUE OF EXACT CLOCKS. — ANCIENT CONTRIVANCES FOR MEASURING TIME. — CURIOUS CLOCKS. — CHANGES IN THE FASHION OF HOUSE CLOCKS. — SEATS OF THE MANUFACTURE OF CLOCKS. — ENGINE FOR CUTTING TOOTHED WHEELS. — DR. FRANKLIN'S CLOCK. — DESCRIPTION OF AN EIGHT-DAY CLOCK. — GOING AND STRIKING PARTS. — MANUFACTURE OF WATCHES. — CLOCKS AND WATCHES IMPORTED AND EXPORTED. DESCRIPTION OF THE PARTS OF A COMMON WATCH. — OLD AND NEW FASHIONED WATCHES. — ESCAPEMENTS. — RECOILING ESCAPEMENT BY CUMMINS. — BY MR. PRIOR. — REID'S ESCAPEMENT. — REMONTOIRE BY DE LAFONS. — DETACHED LEVER ESCAPEMENT. — DIFFERENT SORTS OF PENDULUMS. — PUBLIC REWARDS FOR CHRONOMETERS. — EXTRAORDINARY PERFECTION ATTAINED IN THEIR CONSTRUCTION.

The exact application of correct scientific principles by means of the most perfect workmanship has given to England a decided pre-eminence in the construction of horological machines; while the systematic division of labour pursued in this country has enabled our artizans to produce clocks and watches of uncommon excellence, at such low prices that they constitute a conveniency indispensable except among the lowest orders of the community. The exquisite regularity in the rate of going, which has been attained in chronometers by makers during about a century, is almost incredible; nor will this important object be thought to have been purchased at too great an expense of time and labour, except by those persons (if such there happen to be) who continue ignorant of the vast advantage to be derived from these nearly perfect timepieces in the difficult and dangerous business of navigation.

The ancients had various methods of marking the pro-

gress of time, but none that at all resembled those dependent upon the scientific application of the pendulum or the balance-wheel, even if the use of weights and springs be conceded to a much earlier era than that to which their invention can be satisfactorily traced. The sun-dial, the clepsydra, and the sand-glass, were successively adopted by nations who had not yet acquired a knowledge of the highest application of mechanics. The clepsydra, or water-clock, is undoubtedly an exceedingly ancient invention, and is supposed, by some later authorities, to have borne a resemblance, in one respect at least, to more modern clocks; for one of these instruments, sent by a khalif of Persia to Charlemagne, A. D. 807, is said to have been made of brass, showing the hours by twelve little balls of the same metal, which fell at the end of each hour, and in falling, struck a bell, and made it sound. It had various other fancy movements. The use of the hour glass and the sun-dial has reached to our own times; within about fifty years the latter, in the form of a brass ring, with the hours marked inside, and on the outside a sliding strip, with a small perforation for the sun's rays to pass through, while the instrument was held suspended by a string, was common in the pockets of a class of persons now generally possessing silver watches.

It would be erroneous to imagine that clocks, as we now have them, ought to be attributed to any single inventor; the several parts would doubtless be the production of different persons. It is generally, however, stated, that the art of making clocks such as are now used, was either first invented, or at least revived in Germany little more than 200 years ago. Most writers on this subject have given descriptions of various ingenious clocks, now or formerly to be seen on the Continent, nor does our own country seem to have wanted artists of celebrity in this line.

From the above period, the art of clock-making — to say nothing of the taste for constructing automata — has, like every other handicraft depending on the progress of

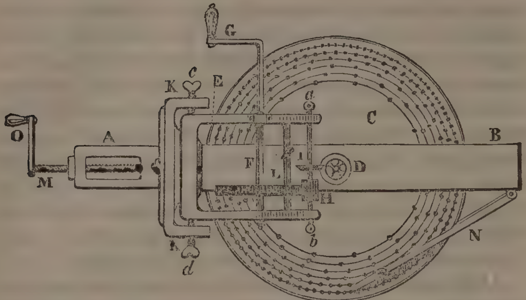
science, undergone many and great alterations and improvements. And, irrespective of the mechanism, few elderly persons can have failed to notice the changes which, exteriorly, the ordinary house-clock has suffered. First, there was the narrow, dark-faced, mysterious looking box, with hour hand only, and a circular glazed hole in the door; then, the respectable oak bodied piece of furniture, bearing date from the beginning of last century — its brass face, silvered hour circle, and blued steel pointers; lastly came the more expensive case of inlaid cabinet work, the handsome painted dial, brass pointers, seconds' index, and, not seldom, other ingenious movements. These are the useful clocks found in almost all the houses of tradesmen, and even the better sort of mechanics, in most parts of England. Among the higher ranks a variety of elegant and expensive timepieces are constantly in demand, the making of which affords employment to a considerable number of hands: "table clocks" of some sort are generally preferred in London, on account of their taking up little room. In addition, may be mentioned the German clocks, having wooden or brass wheels, and which are sold so cheap, with or without "larums" or "cuckoos," that they are met with in thousands of the poorer cottages throughout the kingdom.

It might, perhaps, have been expected, from what we witness in other trades, especially where the working of metal is concerned, that the manufacture of clocks would be found carried on in large establishments, by numerous hands, under one common superintendance; and in such a town as Birmingham, where labour is cheap, where industry and skill are present, and particularly, as there the art of making and working brass so greatly flourishes. This, however, is not exactly the case. Every town, indeed, has its clock-makers, whose business is generally to finish the works sold by the first fabricators in a certain state, put them into appropriate cases, and afterwards clean and keep them in

repair. Chronometers, and the more valuable descriptions of timepieces, are made in London; but great quantities of capital thirty-hours and eight-day clocks are manufactured at Lichfield, Newcastle-under-Lyne, Ashbourn, Darlington, &c. The brass work, however, is commonly cast in Birmingham or Sheffield; while the pinions, and various parts of iron or steel are forged, turned, cut, and sold at surprisingly low prices by the ingenious artizans of Lancashire. The pinions, which should be made of good steel, are formed by striking the metal into a boss, or between a pair of dies, properly hollowed to the wood; they are then rough-turned at the lathe to the proper sizes, after which the leaves are cut with an engine. In this state, without being neatly filed up, or having the pivot ends turned down, they are sold, along with the other forged parts, in sets, to the clock-makers. The wheels and other parts of brass are sold by the founder at so much per pound or set. The wheels are never cast with the teeth upon them, this being impracticable. In preparing them for combination in clock work, they are in the first place neatly filed in the openings, and then, having been bored in the centre, they are carefully and accurately turned on both sides, and on the edge; after which, they are taken to the engine, and the teeth cut on the rim. This engine consists of two parts, — the apparatus for setting out on the periphery of the wheel the requisite number of divisions, and the machinery for cutting the metal at each of these divisions into the form of teeth. *Fig.* 64. is a plan of the engine commonly used by the clock-makers for this purpose. A B is a flat bar or foundation of iron, about thirty inches long and four inches broad; under this bar is placed the dividing plate C, which is about fourteen inches in diameter, made of strong brass, turned exactly smooth and round, and having cut on its upper face a number of concentric circles, accurately perforated with small holes or indentations, at such distances, as to divide each circle into a different number

of parts; the inner circle having, perhaps, only five or eight divisions, and the outer one 360; the intermediate

Fig. 64.



circles being calculated, either by their actual divisions, or by repeating them in the work, to produce a great diversity of numbers, ranging between the two circles. This plate has an upright arbor passing through the iron bar, and upon which is fixed, by means of a screw, the wheel D intended to be cut. The cutting apparatus consists of the frame E, carrying the axis F and its cog-wheel, and terminating in the winch handle G; the cog-wheel actuates a pinion H upon another axle, upon which is fitted the steel cutter I; this axis is sustained, and may be regulated by the screws *a b*, which receive its pivot ends. This frame is contained in the sliding bed-piece K K, and being poised upon the two screws *c d*, the cutter may be raised or lowered at pleasure by means of a screw in the cross-piece L; or the whole may be turned up together, as occasion requires. The screw M passes through a hanging projection at the end of the frame, and into a part of the sliding bed-piece K K, also underneath. The action of the engine will now be easily understood: the wheel D being properly

fastened upon the arbor of the dividing plate, the plate itself is prevented from turning round by means of a screw upon the arm N, which passes over its surface, and has a point which falls into one of the indentations in the circles above mentioned. The plate being thus fixed, the handle G is turned, to give revolution to the cutter, which is made gradually to bear and operate upon the wheel by slowly turning the handle O, to advance the sliding frame. When one tooth has been cut deep enough, the sliding frame is drawn back; the gauge N is released, and the graduated plate moved round until the point falls into the next indentation, where it is fastened, and another tooth of the wheel cut as before — this operation being repeated until the wheel is toothed quite round, which coincides exactly with one entire revolution of the dividing plate.

Differently sized and differently shaped cutters are used for different wheels: that represented in the cut is bevilled on one side, for the purpose of cutting the teeth in the crown wheel of a clock. In forming the other wheels, a square-edged cutter is applied. As this operation leaves the teeth square at the edges, they are either rounded separately by means of a file, or applied to another revolving cutter, which dresses them uniformly and rapidly. The pinions having been properly finished, their leaves accurately filed, and the pivot ends turned down, they are hardened and tempered; after which the wheel is affixed by the following method: — A small piece of brass is bored and slipped upon the spindle of the pinion to the part where the wheel is to be; there it is fastened by soft solder. It is then carefully turned down, until the hole in the centre of the wheel will just slip on, and where, when found to be exactly true, it is riveted fast; the place of junction of the two parts being finally neatly levelled by any application of the turning tool.

Preparatory to the insertion of the wheels and other parts, the two cast brass plates intended to form, as it were, the walls of the machinery, are accurately ham-

mered, squared, smoothed, and perforated with the various pivot holes, &c. For the latter purpose, the two plates are pinned together, and the arrangement of the wheels is drawn upon them, or they are bored by the application of a steel pattern plate. The plates are then separated, the pillars, previously turned; are riveted into one plate, and made to fit through holes in the other; the works are introduced, either between the plates, or they are affixed by means of screws; and in this state the work is generally sold to the clock-maker, who affixes the face, the pointers, weights, pendulum, &c.

One of the least complex forms of construction which the clock can assume is that devised by the ingenious Dr. Franklin, which, while it shows the hours, minutes, and seconds, has but three wheels and two pinions in the whole movement. *Fig.* 65. shows the dial-plate,

Fig. 65.

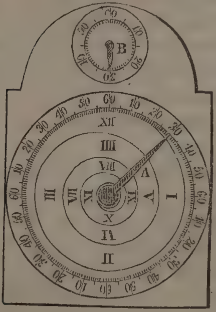
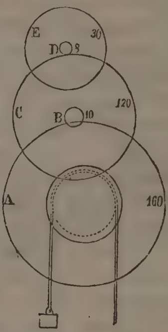


Fig. 66.



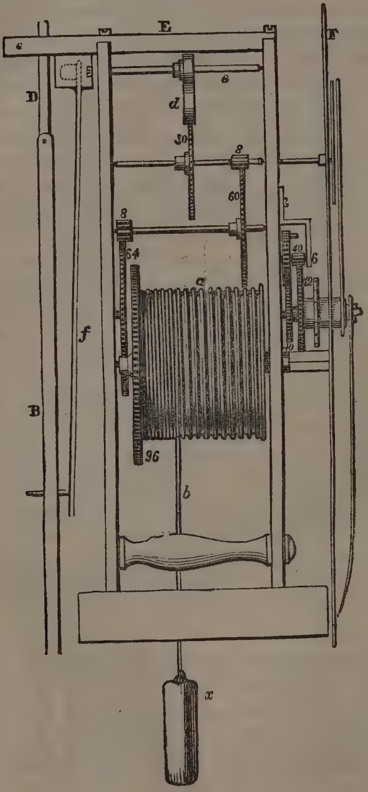
with the hours engraven upon it in spiral spaces about two diameters of a circle, containing four times sixty minutes. The pointer A goes round in four hours, and indicates the minutes from any hour by which it has passed to the next following hour. The time, therefore,

according to the position of the index as shown in the figure, is either thirty minutes past XII, IV, or VIII; and so in every other quarter of the circle it points to the number of minutes after the hours which the index last left in its motion. The small hand B, in the arch at the top, goes round once in a minute, and shows the seconds. The wheelwork of the clock is shown in *fig.* 66. A is the great wheel, containing 160 teeth, and going round in four hours, carrying the pointer, which is let down by a hole on its axis. This wheel turns a pinion B of ten leaves, which, therefore, goes round in a quarter of an hour. On the axis of this pinion is the wheel C of 120 teeth, which goes round in the same time, and turns the pinion D of eight leaves round in a minute, having the seconds' hand on its axis, and also the click wheel E of thirty teeth, for moving by pallets a pendulum that vibrates seconds. This clock is wound up by a line going over a pulley, with a ratchet stop on the axis of the great wheel. An improved clock on this principle of construction, but which both shows the hours more explicitly by means of another contrivance, and also requires seldomer to be drawn up, has been described by the late ingenious Mr. Ferguson: other alterations have been proposed and made by different individuals.

Figs. 67., 68., and 69. comprise a representation of the ordinary eight-day clock, including the mechanism for striking the hours. *Fig.* 67. is an elevation of the clock sideways, showing the pendulum and the going part, the striking movements being omitted to prevent confusion: *fig.* 68. is a projection of the wheelwork of both the going and striking part; and *fig.* 69. is the dial-work, or mechanism on the outside of the front plate, and immediately under the face (which is removed); it is that part which puts the striking train in motion every hour. A clock of this kind contains two independent trains of wheelwork, each with its separate first mover: one is constantly going, to indicate the time by the hands on the dial-plate; the other

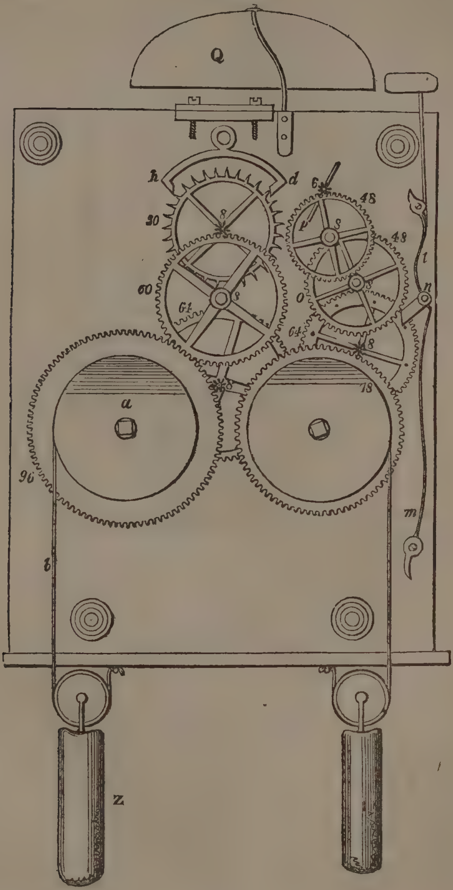
is put in motion every hour, and strikes a bell to announce the hour at a distance. A variety of table clocks, actuated by a spring, and containing only the going train, are produced by the London makers at moderate prices, the instrument being much simplified by the

Fig. 67.



absence of the repeating mechanism, even when it is merely required to strike the quarters.

Fig. 68.



In *figs.* 67. and 68. *a* is the barrel of the going part; it has a catgut band *b* attached at one end, and wound round the cylinder, the other end being fastened to the foundation support; on it is suspended the weight Z, of about 12 lbs., which keeps the clock going. Instead of thus hanging a heavy weight upon the hook of a pulley, acting on the loop of a double string, the clock would act the same if a lighter weight were simply suspended by a knot at the end of a single string, in the manner of *x* (*fig.* 67.); with this difference, however, that the case of an eight-day clock would require to be twice as deep in the latter as in the former arrangement. The great wheel 96, so numbered, in common with those that follow, in reference to the number of its teeth, is fixed upon the end of the barrel, turning a pinion of eight leaves on an arbor which carries the minute-hand. The centre wheel 64 is placed on the same arbor, turning the wheel 60 by a pinion of eight leaves on its arbor: this last wheel acts on the pinion of eight, on the arbor of the swing wheel 30; *d h* are the pallets of the escapement fixed on the arbor *e* (*fig.* 67.), going through the back plate of the clock, and carrying a lever *f*: this lever has either a small pin projecting from its lower end, as shown in the figure, going into an oblong hole made in the rod B of the pendulum; or else the lower end is bent outward, having a groove through which the rod passes. The pendulum consists of a metallic rod, commonly suspended by a bit of slender steel spring D from the bracket E: it has a flat weight, called the bob, at its lower end, and, in the clock under description, 39·125 inches from the point of suspension. When this pendulum is moved from the perpendicular line in either direction, and suffered to fall back again, it swings nearly as much beyond the perpendicular on the contrary side, and then returns; this it will continue to do for some time, and each of these vibrations will be performed in one second of time, when the pendulum is of the above length. This suspended rod is, in reality, the measurer of time, and the

office of the clock is only to indicate the number of vibrations it has made, and give it, through the action of the swing-wheel on the pallets, a small impulse each time to keep it going, as the resistance of the spring and of the air would otherwise, in a few hours, cause it to stop. The distance between the two pallets *d h* is so adjusted, that only half a tooth of the wheel escapes at each vibration; and as the wheel has thirty teeth, it will revolve once in sixty vibrations of one second each, or one minute; consequently, a hand on the arbor of this wheel will indicate seconds on the dial-plate F; the pinion of eight on its arbor is turned by a wheel of 60, which, consequently, will turn once in seven turns, and a half of the other, or in seven minutes thirty seconds, or one eighth of an hour; its pinion of eight is moved by a wheel of 64, or eight times itself, which will turn in one eighth part of the time; this will be an hour; the arbor of this wheel, therefore, carries the minute-hand of the clock. The great wheel of 96 being twelve times the number of the pinion eight, will turn once in twelve hours, and the barrel *a* with it. The gut goes round sixteen times, so that the clock will go eight days.

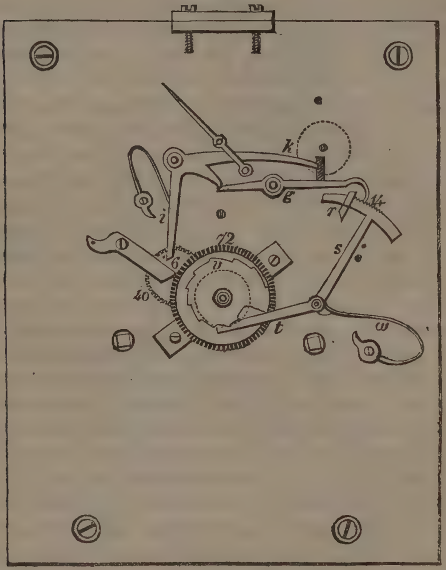
The hour-hand of the clock is turned by the wheel-work, as shown in *fig.* 67. On the end of the arbor of the centre wheel 64, a tube is fitted, so as to go round with it by friction; this carries the minute-hand; but, if the clock should require correction, the hand may be slipped round without moving the wheels: this tube has a pinion of forty teeth on its lower end, indicated by a dotted circle; this turns another wheel, 40, which has a pinion of six teeth on its arbor, turning a wheel, 72; the two wheels, with forty teeth, will both turn in an hour; and 72, in twelve hours: the arbor of this wheel has the hour-hand, and consists of a tube going over the arbor of the minute-hand, so that the two are concentric. The barrel *a* has a stout arbor coming through the front plate and dial of the clock, and is filed square to put on a key to wind up the weight. The great

wheel, 96, is not fixed fast to the arbor, but merely fitted upon it, and having a click, which takes the teeth of a ratchet wheel cut upon a raised rim at one end of the barrel; so that the barrel may be turned in the direction to wind up the weight, without moving the wheel, which, through the action of the click, is immediately operated upon again by the weight, when the key is removed.

Having now described the going part of the clock, it remains to describe the mechanism by which the hours are struck. In *fig.* 68., the great wheel, 78, has a barrel and click the same as that of 96 teeth already described: it turns a pinion of eight; 64 is a wheel on the same arbor, turning a pinion of eight on the arbor of the wheel *o*, of 48; this turns another pinion of eight, and wheel *p*, of 48; which turns a pinion of six, on the same arbor with a thin vane or fanner of metal called the fly, and which, by the resistance of the air to its motion, regulates the velocity of the wheels. The wheel 64 has eight pins projecting from it; these raise the tail *n* of the hammer as they revolve, and the hammer is returned smartly when the pins leave its tail, by a spring, *m*, pressing on the end of a pin put through its arbor, and strikes the bell, Q; *l* is a short spring, which the other end of the pin, through the arbor, touches, just before the hammer comes into contact with the bell; its use is to bear the hammer off the bell the moment it has struck, that it may not jar or stop the sound. The eighth pin in the wheel 64 must pass by the hammer tail seventy-eight times in striking the twelve hours, and, as its pinion has eight leaves, each leaf of the pinion answers to a pin in the wheel 64; now, as the great wheel has 78 teeth, it will turn once in twelve hours, the same as the other great wheel, 96. In the wheel 64, eight of its teeth correspond to one of the pins for the hammer, and, as the pinion of the wheel *o* has eight teeth, the wheel itself will turn once for each stroke of the hammer, the fly, meanwhile, turning 48 times.

Fig. 69. is also mechanism relating to the striking part; *r* is a small pinion of one tooth, called the ga-

Fig. 69.



thering pallet, on the arbor of the wheel *o*, and, consequently, turns once for each stroke of the hammer; *s* is a segment of a large wheel, or rack, which it turns; *t* is an arm attached to the rack, whose end rests against a spiral plate, *v*, called the snail; this is fixed on the tubular arbor, before described, of the hour-hand and wheel 72, and turns round with it once in 12 hours. The plate is divided into 12 equal angles, 30 degrees each; and, as it turns, each of these answers to an hour: the circular arcs, forming the circumference of the snail, are struck from the centre of the arbor be-

tween each division, with a different radius, decreasing a certain quantity each time in the order of the hours. The circular part of the rack *s* is cut into teeth, each of which is of such a length, that every step upon the snail shall answer to one of them; *w* is a spring pressing against the tail of the rack, and acting to throw the arm of the rack against the snail; *g* is a click called the hawk's-bill, taking into the teeth of the rack, and holding it up in opposition to the spring; *i k* is a three-armed detent, called the warning-piece; the arm *k* is bent at its end, and passes through a hole in the front plate of the clock, so as to catch a pin placed in one of the arms of the wheel *p* (*fig.*68.), and which describes the dotted circle in *fig.* 69.; the other arm, *i*, stands so as to fall in the way of a pin in the wheel 40. In the figure the striking train is represented as in motion, to which it is brought as follows: — The wheel 40, as already stated, turns once in an hour, and, consequently, at the expiration of every hour, the pin in it takes the end *i*, and moves it towards the spring near it; this depresses the end *k*, until it falls in the circle of the motion of the pin in the wheel *p* (*fig.*68.), at the same time that the short tail depresses one end of the hawk's-bill, and raises the other, *g*; immediately the spring *w* throws the rack back, until the end of its tail, *t*, touches that part of the snail which is nearest it; when the rack falls back, the pin in it is moved clear of the gathering pallet, *r*, and the wheels set at liberty; the maintaining power puts them in motion; but before the hammer has struck, the pin in the wheel *p* falls against the end of *k*, and stops the whole; this takes place a few minutes before the clock strikes the hour, and the noise of the wheels turning is called the "warning;" some persons have thought it would be better if the clock had not to perform this operation.

When the hour is expired, the wheel 40 has turned so far as to allow the end of *i* to slip over its pin, when the small spring pressing against it, raises the end *k*, so as to be within the circle of the wheel *p* (*fig.*67.). Every obstacle being now removed, the wheel, 64, raises the

hammer *r*, and it strikes the bell; the gathering pallet takes up the rack, a tooth at each turn, the hawk's-bill retaining it until the pin in the rack comes under the gathering pallet, and stops the motion of the whole till the pin in the wheel 40, at the end of the next hour, takes the warning-piece, and repeats the entire operation. As the gathering pallet turns once for each blow of the hammer, and its fang gathers up one tooth of the rack at each turn, it is evident that the number of teeth the rack is allowed to fall back limits the number of strokes the hammer will make. This is secured by the resting of the tail of the rack on the snail; each step of the snail answers to one tooth of the rack, and one stroke of the hammer; at each hour a fresh step of the snail is turned to the tail of the rack; and, by this means, the number of strokes is made to increase, one at each hour's end, from one to twelve.

The manufacture of watches, as already mentioned, constitutes one of the important staple trades of this country. The principal seats of the art are London, Coventry, and Liverpool. English-made watches enjoy considerable reputation abroad, and, consequently, fetch high prices; and it is to be regretted that this distinction, so deservedly sustained by the best genuine articles, should be undermined, not merely by the exportation of flash workmanship — for let them who will make, sell, and buy cheap watches, — but by an unprincipled practice of engraving upon such worthless things the name of some maker of reputation. These "Jew watches," as they are called, are often finished with great neatness outside, but the cases are light, the movements, often obtained from abroad, very flimsy, so that the whole prices do not, sometimes, average much above 1*l.* each to the wholesale customer. In addition to the clocks and watches manufactured in this country, great quantities of movements are imported; these are charged an *ad valorem* duty. The value of foreign clocks imported in 1832 was declared to be 25,332*l.*; of these, there were re-exported to the value of 1053*l.* 10*s.* The importation of watches, in the same year, was

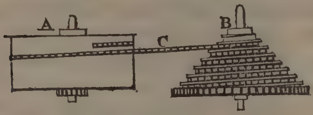
2298*l.* 4*s.*, of which the greater part, namely, to the amount of 2088*l.* 5*s.*, were re-exported. Of British manufactured clocks, there were exported, in 1833, to the amount of 3484*l.* declared value: the number of watches exported, during the same twelvemonth, was 18,678, including six ship's chronometers; all being, with the exception of 671 sets of movements, fitted with gold, silver, or metal cases.

The labour is extensively distributed, there being about thirty distinct branches. One party produces the steel springs; another, called the "movement makers," the wheelwork generally; a third, the chains, the delicate manufacture of which is chiefly carried on at Whitchurch, Hants; a fourth, the dials, which are enamelled discs of thin copper; a fifth, the hands; a sixth, the cases, and so on. Watch-work demands the utmost delicacy of manipulation in the manufacture, the parts being mostly executed under a high magnifying power. The wheels, the brass for which is required to be of the very best and finest quality, are first turned to the proper size, and afterwards cut by a machine, similar in principle to that previously described for cutting clock wheels. The steel arbors on which the wheels are fixed, are turned out of pinion wire, the leaves being left on the shaft where wanted, while the superfluous metal is removed by the application of the tool. Instruments appropriate to all the purposes of watch-making are made by the more celebrated Lancashire tool-makers.

In the mechanism of the common pocket watch, the wheels between the plates differ from those of the clock above described, not only in size, but also in number, position, number of teeth, and other particulars: the most striking differences, however, are, that instead of the weight and pendulum, the prime mover is a coiled riband-like spring of steel, while the beat is made to depend upon the action of the pallets of what is commonly called the verge, upon the balance-wheel. The little shallow circular box, A, containing the spring,

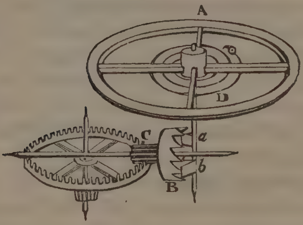
and the fusee, B, with the chain C, connecting them, are shown below (*fig.* 70.). The prime move-

Fig. 70.



ment of the various elegant table clocks is exactly similar to the foregoing, and on a scale of enlargement proportionate to the size of the connected works. The appearance and combination of the balance with the balance-wheel, the former performing in the watch that office which, in most clocks, is performed by the pendulum, is shown in *fig.* 71. A is the balance, being a

Fig. 71.



circular fly of burnished steel, delicately poised by the pivots of its arbor, which is called the verge, and upon which are the two fins, *a b*, placed at different angles, and acted upon alternately by the teeth of the cylindric balance-wheel B, placed vertically, and deriving its momentum from the train by the pinion C. The instant recoil of the balance after each release of the pallet from a tooth of the wheel is produced by the heliacal hair-spring D, shown in its place as coiled under the fly, to which one end is attached, and the other

passing through a sliding pin in the plate, affords a means of regulating the watch, by increasing or diminishing the length and consequent action of the spring. These springs are of steel wire, exquisitely drawn and tempered, and afford, in their manufacture, the most striking illustration known of the transcendant value imparted to a cheap material by workmanship.

The wheelwork of an ordinary watch, and its operation, may, perhaps, be understood from the following description: — The chain being fixed at one end to the wider part of the fusee, and, at the other, hooked to the barrel or box containing the spring, when the machine is winding up, the fusee is turned round by the application of the key, and, of course, the barrel turns also; on its inside is fixed one end of the spring, the other being fastened to an immoveable axis in its centre. As the barrel moves round, it coils the spring several times about the axis, thereby increasing the elastic force to a proper degree; meanwhile the chain is drawn off the barrel upon the fusee: and when the winding up is complete, and the key removed, the spring, by its elastic force, endeavouring constantly to unbend itself, acts upon the barrel by carrying it round, by which the chain is drawn off from the fusee, thus turning it, and, therewith, the whole of the machinery. Now, as the spring unbends itself by degrees, its elastic force, by which it affects the fusee, will gradually decrease; and, therefore, unless there were some mechanical contrivance in the figure of the superficies of the fusee, to cause that, as the spring grows weaker, the chain shall be removed farther from the centre of the fusee, so that what is lost in the spring's elasticity, is gained in the length of the lever, — were it not for this contrivance, the spring's force would always be unequal upon the fusee, and thus turn it, and, consequently, the whole machinery, unequally. All this is remedied by making the fusee conical, the chain falling into a spiral groove cut about its periphery.

When the watch is wound up, the chain from the

spring exerts a force, through the fusee, upon the great wheel of 48 teeth, acting on a pinion of twelve leaves, on the arbor of the centre wheel of 53 teeth, which takes a pinion of six on the axis of the third wheel of 48 teeth, and which, acting on another pinion of the same number, drives the contrate wheel of 48 teeth; this acts upon the six-leaved pinion of the balance-wheel, the fifteen teeth of which give that impulse to the verge pallets, which keeps the balance in motion. Such is, in general, the mechanism of a thirty-hour watch, as it lies between the plates, and serves to indicate the minutes, seconds, and quarter-seconds of an hour: for measuring the hours of the day, there is other machinery between the upper side of the pillar plate and the dial-plate. The middle of the plate is perforated with a hole receiving the end of the arbor of the centre wheel, which carries the minute-hand; near the plate is fixed a pinion of ten leaves; this is called the pinion of report; it drives a wheel of 40 teeth, which carries a pinion of twelve leaves, acting on a wheel with 36 teeth. As in the body of the watch, the wheels every where divide the pinions; so here, on the contrary, the pinions divide the wheels, and, by that means, decrease the motion, which is here necessary; for the hour-hand, which is carried on a socket fixed on the wheel with 36 teeth, is required to move but once round, while the pinion of ten leaves moves twelve times round.

The old-fashioned watches, as every one must have noticed, are considerably more chubby than those of modern construction, which are much more compressed in appearance, and are consequently both more elegant and more convenient. This improvement has been effected, in the first place, by sinking the third wheel into the front plate; and, on this account, these were commonly, at first, called "sunk wheel watches;" and, secondly, by shortening the axles of the wheels, and, consequently, the fusee: to allow of this latter alter-

ation, the fusee must either be enlarged in its diameter, or the chain must be reduced in thickness; these expedients are generally combined; but the delicacy attained in the construction of the chains for some very thin watches is greatly at the expense of their durability. Watches are sometimes fitted with a bell and other machinery for striking the hours, ringing an alarum at a given time, or, more commonly, for repeating any number of times, on pushing a spring, the hour and quarter last passed, so that a person in the dark may easily ascertain the time: these watches — more properly, pocket clocks — are called repeaters.

The two points to which modern science has been so successfully applied, in the perfection of horological machines, are the escapement and the pendulum; and both have been indebted to those resources of practical ingenuity, which first-rate artists alone can either furnish or appreciate. What follows is chiefly derived from a notice of these improvements in an elaborately compiled chapter of Nicholson's "Operative Mechanic." The motions of a clock or watch, as we have already seen, are regulated by a pendulum or balance, which serves as a check, without which, the wheels impelled by the spring or the weight, would run round with an accelerated motion until the force of the primum mobile was spent: when, however, the pendulum or balance is put in the way of this motion, in such a manner that only one tooth of a wheel can pass, the revolutions are made to depend on the vibration of the pendulum or balance. As the motion of these regulators is alternate, while the pressure of the wheels is constantly in the same direction it is necessary to employ some means to adapt these different motions to each other; "now, when a tooth of the wheel has given the pendulum or balance a motion in one direction, it must quit, that the pendulum or balance may receive an impulsion in the opposite disection: this escaping of the tooth has given rise to the term escapement."

Fig 72.

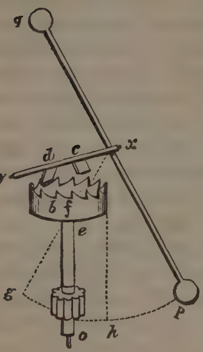
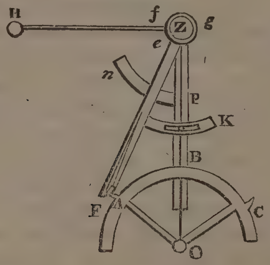


Fig. 72. in the margin represents the ordinary *recoiling* escapement, exactly similar in principle to that previously shown in connection with the balance-wheel of a watch: here, it is applied to what in a clock is called the crown-wheel. Its action may be thus illustrated: let *x y* represent a horizontal axis, to which the pendulum is attached by a slender rod: this axis has two leaves, *c* and *d*, one near each end, and not in the same plane, but so that when the pendulum hangs perpendicularly at rest, *c* spreads a few degrees to the right, and *d* as much to the left; these are called the pallets. Let *f b* represent the crown-wheel turning on a perpendicular axis *e o*, in the order *e f b*. The teeth of this wheel, generally an odd number, are in the form of those of a saw, leaning forward in the direction of the rim's motion; in the figure, the pendulum is represented at the extremity of its excursion towards the right, a tooth having just escaped from one pallet and dropped on the other. "Now it is evident that, while the pendulum is moving to the left, in the arc *p g*, the tooth in contact with the pallet *d* still presses on it, and thus accelerates the pendulum, both in its descent along *p h* and its ascent up *h g*, and that when *d*, by turning round the axis *x y*, raises its point above the plane of the wheel, the tooth *b* escapes from it, and *i* drops on *c*, now nearly perpendicular: thus *c* is pressed to the right, and the motion of the pendulum along *g p* is accelerated. Again, while the pendulum hangs perpendicularly in the line *x h*, the tooth *b*, by pressing on *d*, will force the pendulum to the left, in proportion to its weight, and, if it be not too heavy, will force it so far from the perpendicular, that *b* will escape, and *i* will catch on *c*, and

force the pendulum back to *p*, when the same motion will be repeated. This effect will be the more remarkable, if the rod of the pendulum be continued through *x y*, and have a ball *q*, on the other end, to balance *p*."

In considering the utility of any improved escapement for clocks, it is necessary, as Mr. Nicholson justly remarks, to keep in mind the proposition that the natural vibrations of a pendulum are isochronous, or are performed in equal times: the object of the escapement is to preserve this isochronous motion of the pendulum. Of contrivances to answer the aforesaid purpose, the escapement devised by Mr. Cumming is at once ingenious in its construction and perfect in its operation. A front view of this escapement is shown below (*fig*.73.): A B C represent a portion of the swing wheel,

Fig. 73.



of which O is the centre, A one of the teeth, and Z the centre of the crutch, the pallets and pendulum. The crutch is somewhat of the form of the letter A, having in the bent cross-piece a slit at K; the arm Z F forms the first detent, and the tooth A is represented as locked on it. The first pallet is on the end of an arm lying wholly behind the arm Z F of the detent, and fixed to a round piece of brass, *e f g*, having the same centre as the detents, and turning on pivots concentric to the axis of the pendulum; to the same piece of brass is fixed a horizontal arm, carrying at its extremity the

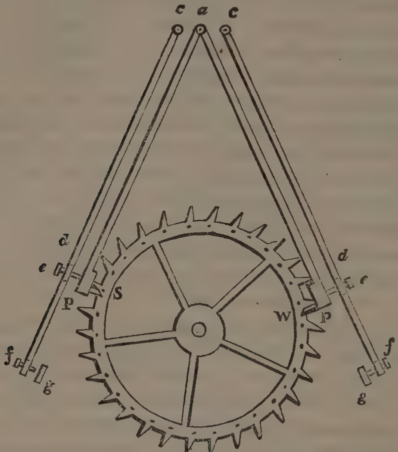
ball H, of such size that the action of the tooth A on the pallet is just able to raise it to the position represented: Z P represents the fork or pendulum rod, behind both detent and pallet; a pin projects forward through the slit at K, without touching either margin of it. Attached to the fork is the bent arm *n*, of such length, that when the pendulum rod is perpendicular, the angular distance of the piece *n* from the rod *e* H is just equal to the angular distance of the left side of the pin in the centre of the slit K. It is not necessary to describe in detail the modus operandi of this escapement; it may, however, be stated, that both pallets and detents are detached from the pendulum, except in the moment of unlocking the wheel; so that, except during this short interval, the pendulum may be said to be free during its whole vibration, and of course, its motion is more equable and undisturbed.

In the transactions of the Society of Arts for 1812, are figures and a description of a remontoire escapement constructed by Mr. Prior, which possesses considerable merit, and for which he was rewarded by the Society. "The advantage of this escapement is such as 'will give an exact and equal impulse to the pendulum without any friction, and which cannot be at all affected by any irregularities or variations arising by the clogging of oil and increasing of friction from the train, except during the very small part of the vibration that the pendulum is removing the spring detents from off the points of the teeth of the escape-wheel, the effects of which can never be discovered in the rate by any variation the oil on the pivots and the increase of friction can ever produce, as long as the wheels will be able to wind up what is called the 'renovating spring,' which will be nearly as long as they can move at all; as the renovating spring has not either to be wound up quick, or to be pushed beyond any catch or spring to keep it in its proper situation, nor can there ever be any increase of friction in winding up the spring, as it is formed in nearly as right a line as possible; consequently, must go almost

endlessly without cleaning, and will never require any oil."

The annexed cut (*fig.* 74.) is a representation of the

Fig. 74.

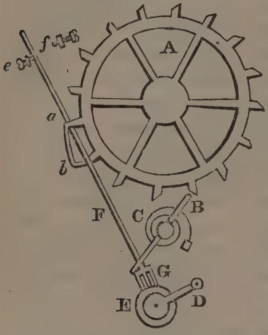


clock escapement contrived by Mr. Reid of Edinburgh, author of a work on clock and watch making. It was thus described in the Edinburgh Encyclopædia:—S W is the swing-wheel, whose diameter may be so large as to be sufficiently free of the arbor of the wheel that runs into its pinion, which in eight-day clocks is the third; the teeth of this swing-wheel are cut thus deep, in order that the wheel may be as light as possible, and the strength of the teeth little more than what is necessary to resist the action or force of a common clock-weight through the wheels; they are what may be called the locking teeth. The impulse teeth consist of very small tempered steel pins inserted on the surface of the rim of the wheel, on one side only; they are nearly two tenths of an inch in height, and the smaller they are, so much more room will be given for the

thickness of the pallets. P P are the pallets, whose centre of motion is the same as that of the verge at *a*. That part of the pallet frame, as it may be called, in which is set the stone, for receiving the action or impulse of the small pin teeth, is shown at P P, in connection with the teeth; the form of the pallet stones is that which gives the dead beat; *d d* are the detents, whose centre of motion is at *c c*. The screws, *e e*, *f f*, in the arms of the detents, are for adjusting the pallets, and regulating the effect of the detents on the locking-wheel; the two latter screws fall upon the studs *g g*. Having described the parts, the following will enable the reader to understand their mode of action:—On the left-hand side the pin tooth is represented as having just escaped its pallet; but, previous to its having got on to the flanch of this pallet, let us conceive that the back, or end piece of it, had come, in consequence of the motion of the pendulum, to that side, and opposing the screw *e*, which is in the detent arm, pushes or carries it on with it, and consequently unlocks the tooth of the wheel, which then endeavours to get forward; but the pin tooth, at this instant of unlocking, meeting with the flanch of the pallet at the lower edge inside, and pushing forward on the flanch, by this means impels the pendulum, and after having escaped the pallet, the next locking tooth is received by the detent on the right-hand side, where the wheel is now again locked. In the mean time, while the pendulum is describing that part of its vibration towards the left-hand free and detached, as the pallets are now at liberty to move freely and independently of the small pin teeth, on the return of the pendulum on the right-hand side, the detent, by means of the pallet on that side, is pushed out from locking the wheel, and at the instant of unlocking the wheel gets forward, and the pin tooth is at the same instant ready to get on the flanch of its pallet, and thus gives new impulse to the pendulum. After the pin tooth has escaped the pallet, the wheel is again locked on the opposite or left-hand side; the pendulum,

moves on to the right freely and independently till the next locking on the left takes place, and so on. It is stated that a clock, to which this escapement was fixed, was observed from time to time with a very good transit instrument, and during a period of eighty-three days, it kept within the second, without any interim apparent deviation.

Fig. 75.

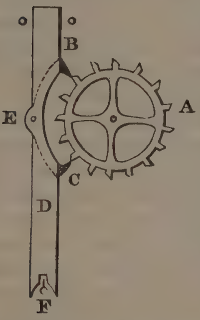


The annexed cut (*fig.*75.) represents an escapement some years since laid before the Society of Arts by the inventor, M. Delafons; it exhibits ingenuity and comparative simplicity, and is thus described by the artist who made it, and who, in his communication to the above-named society, alludes to the scientific labours of two of his predecessors in this interesting department, Mr. Mudge and Mr. Haly, individuals to whom horological mechanism is greatly indebted. A shows the scape wheel; B, the lever pallet on an arbor with fine pivots, having at the lower end, C, the remontoire or spiral spring, fixed with a collar and stud, as pendulum springs are; D, the pallet of the verge, having a roller turning in small pivots for the lever pallet to act against; E, pallets to discharge the locking, with a roller between; F, the arm of the locking pallet, continued at the other end to make it poise, having studs and screws *e*, *f*, to adjust and bank the quantity of motion; *a* and *b*, the locking pallets, being portions of circles fastened on an arbor turning on fine pivots; G, the triple fork, at the end of the arm of the locking pallets. According to the inventor, the action of this improved remontoire detached escapement for chronometers is so adapted, that it gives a perfectly equal impulse to the balance, and at the same time entirely removes whatever ir-

regularities arise from the different states of fluidity in the oil.

Most of the better sort of watches are now made with a detached lever escapement. The lever itself, as originally patented to a Liverpool watchmaker some years ago, terminated at one end in a toothed sector, acting upon the balance through a pinion on its arbor during each impulse of a tooth on the balance wheel. The advantages even of the rack lever were so manifest, that a method was presently devised for detaching it from the balance during the greater part of the gyrations of the latter. The subjoined diagram will illustrate the principle of the lever, which in its action greatly resembles that of the pendulum of a clock.

Fig. 76.



Suppose A (*fig.* 76.) to be the balance wheel, and B C the pallets of a dead-beat escapement, as in the better sort of clocks. The piece of steel in which these pallets are filed is affixed to the under side of the lever D, having its axis at E, or coincident with the centre of motion in the pallets. At one end of the lever is a semicircular hollow with a nick in its centre, and which, catching the spur on the balance axle F, swings the balance round; one of the pallets remaining locked upon a tooth of the wheel, until the action of the balance causing its spur to act on the opposite side of the nick, the pallet is removed from the tooth of the wheel, and the balance is again impelled backward. The other end of the lever strikes alternately against two pins, placed at proper distances, to prevent it from flying beyond the reach of the spur on the balance arbor.*

* For further particulars respecting pendulums, see MECHANICS, Cab. Cyclo.

CHAP. XVI.

BRASS TOYS AND PINS.

BIRMINGHAM CELEBRATED FOR ITS SMALL WARES. — SOHO. — CLASPS AND BROOCHES. — PINS. — STATUTES CONCERNING PINS. — GLOUCESTER AND LONDON. — IMPORTANT RESULTS FROM A DIVISION OF LABOUR IN THE MANUFACTURE. — PREPARING THE WIRE. — POINTING AND CUTTING UP. — HEADING. — PATENT HEADS. — MR. WRIGHT'S PATENT MACHINERY. — WHITENING AND PAPERING.

Birmingham, "the toy-shop of the world," supplies a prodigious quantity of small articles, of which it would be as difficult to prove the usefulness as to dispute the beauty. Ornament and utility, when applied to this class of manufactures, are terms of such convertible import, that it would not be easy to fix the precise meaning of each, beyond the reach of dispute. Every one admits that a watch-key is an indispensable accessary to a watch, but by many persons the chain might be denounced as superfluous — and still more so the seal; though the latter, especially if containing an engraved stone or a piece of embossed glass, is not without its occasional use, and may even become of great importance as a signet. The science of optics has, perhaps, been really more advantageous to mankind in aiding the eyesight, and in protracting the use of the visual organ for the ordinary purposes, than in bringing us acquainted with the wonders of the telescope and the microscope; and the mounting of a lens so as to be momentarily convenient, is carrying, as it were, beyond itself, even the spectacle maker's art: and yet there is no affectation carried to a more ridiculous extent than that of pretending to have defective eyes for the sake of wearing a spying-glass. A great variety of ingenious contrivances for fastening the different articles of the dress of both

sexes, ought by no means to be excluded from the list of manual and mechanical operations, to which is applied the distinction of useful arts. A hook and eye would, indeed, fasten a lady's tippet—and if the utensil were formed on the improved principle, it might not be very liable to work loose; but a snap, as the little box and bit of bent wire are called, is a far safer, as well as a much neater fastening. A gentleman's cloak might be secured by a button and a loop; but the claw latchets and links, so generally worn, are not more ornamental than convenient.

Trinkets, properly so called, are of a widely different class: and, whether worn upon the dress, the fingers, or in the ears, and exhibiting, as they often do, the most exquisite workmanship, can certainly never be regarded as useful in the ordinary sense of the term — even though they happen to adorn or even become the wearer. Articles of this description, although originally composed of the precious materials, and combining in their fabrication the delicate arts of the goldsmith and the jeweller, are every day imitated in brass by the Birmingham artists, who at least derive an honest livelihood from this exercise of their ingenuity. Some of them, indeed, have done a great deal more: the Soho, that wonderful creation of one master mind, and latterly more renowned for its coining works and its steam-engines than even for its manufactures in bronze and or-molu, once under the patronage of royalty, originated in the production of superior gilt toys and trinkets. "The eminence from which this celebrated establishment takes its name," to quote an elegant description, it was once a barren heath, on the bleak summit of which stood a naked hut, the habitation of a warrener. At the bottom of it, however, there ripples a little stream, the capabilities of which attracted the discriminating eye of Mr. Bolton. He bought the land, and expended a sum more than equal to the half of his patrimony, in building workshops and dwellings for upwards of 600 artizans. The water of the rivulet he

collected into a pool, and made it fall on a water-wheel, which communicated motion to an amazing number of different machines and implements, by whose agency were fabricated, in the highest elegance and perfection, utensils of many kinds in gold, silver, tortoiseshell, and enamel; and many vitreous and metallic compositions, with gilded, plated, and inlaid works. As the works rapidly extended, the power of horses was, for a short time, employed in aid of the water-wheel; but these were at length superseded by an engine on Savory's construction, and, finally, by the Bolton and Watt engines. The presiding genius of the place, who was furnished from the varied operations of this museum of mechanical wonders with the highest entertainment as well as most lucrative employment, kept hospitality in a mansion on the other side of the hill, which he surrounded with a beautiful garden, having the charms of shady groves, velvet lawns, and sparkling water."

From the antique specimens of one kind of trinket—the brooch—has originated the common pin, the smallest, but at the same time the most universally demanded, not to say most useful, product of the inferior operations in brass. The brooch is undoubtedly a modification of the fibula of antiquity, which was a sort of buckle or clasp, used by the Greeks and Romans for keeping close or looping up some part of their clothes: they were of various forms, and often adorned with precious stones. The ancient Highlanders wore brooches of gold and silver, some of them of a large size, set with precious stones, or containing glazed cells for the reception of relics or other rarities.

The cheap articles of the classes above mentioned are mostly composed, in the larger sorts, of fine brass, and in the smaller, often of what is significantly termed "jewellers' gold," which may either mean gold of half-standard purity, an alloy of copper, gilt, or a fine yellow composition metal, consisting of copper and zinc in about equal proportions. The last is the Mosaic gold, or Parker's metal, as it is sometimes called. Prince's metal, an alloy somewhat resembling gold, and which

was so denominated after prince Rupert, who patronised the manufacture, consisted of copper, with only a trifling admixture of zinc, as did also a composition called, from its inventor, pinchbeck, and which was a good deal used about 1760 for watch-cases and toys in general. It would be futile to attempt to describe in detail the endless methods adopted by the artizans of Birmingham and other places in the manufacture of gilt and lacquered toys of the before-mentioned metals: they are, indeed, comprised in the use of tools and contrivances for the most part already mentioned. Before we describe in detail the making of pins, it may be interesting to observe that, in a kindred article, brass thimbles, the consumption is exceedingly great, notwithstanding the cheapness, and consequent extensive use of silver ones. Any person who may happen casually to notice one of these apparently insignificant but really indispensable little articles, as they are made now-a-days, cannot but be struck with their improved appearance as compared with those made formerly.

Pins, as already intimated, have in their use and manufacture succeeded the ancient fibula: the transition, however, was not made at once, but gradually. Until nearly the middle of the sixteenth century, the females of this country made use of skewers of gold, silver, brass, and even of wood, in various parts of their dress: some of these would, of course, have ornamented heads, in the manner of our "breast pins," but clumsier in make. Soon afterwards we find that pins began to be made in England, probably in imitation of those introduced from abroad. The manufacture presently became of sufficient importance to engage the attention of parliament, towards the latter end of the reign of Henry VIII. We may, however, infer from the statute then made "concerning pins," that the article known by that name in 1543, was very different from what we now see. The act sets forth that "no person shall put to sale any pins but only such as be double-headed, and have the heads soldered fast to the shank of the pin;

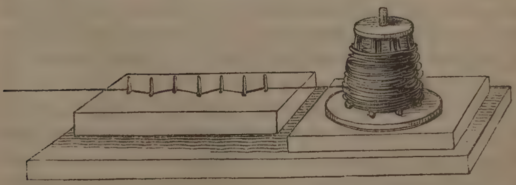
well smoothed, the shank well shaven, the point well and roundly filed, canted, and sharpened." The labour of making pins after this manner, as it must have rendered them very expensive, shows the novelty of the invention, which was probably but a little before brought from France. The high price and inconveniency of the make of those pins naturally set the English workman upon improving so tedious and clumsy a manufacture, and in about three years time something like the present ingenious and expeditious mode of making them had been hit upon, as may be inferred from the repealing of the above statute. We are told that the pin manufactory was introduced into Gloucester about 1626, by a person of the name of Tilby: that city subsequently became noted for the perfection of its pins, and the great number of houses employed in making them, — 1500 persons having at one time earned their livelihood by this occupation. It has been stated, too, that some years since, pins were sent annually to the metropolis to the amount of 20,000*l.*, in addition to which the manufacturers enjoyed an extensive trade with Spain and America. In 1636, the London pin-makers obtained a charter of incorporation, with a master, two wardens, and eighteen assistants. Not only in London, however, but to a large extent in Birmingham, as well as in several other places, the manufacture of pins is carried on. As this is a branch of industry from which results an article astonishingly cheap as compared with the great number of hands through which each pin passes, it has been selected by Dr. Adam Smith, and other writers on political economy, as illustrative of the working of an important principle — "the division of labour."

Most of the writers here alluded to begin by describing the processes by which brass is made into wire: these, though undoubtedly belonging to the manufacture of a pin, separately considered, are not in reality carried on in any establishment where pins are made. In the workships where pins are formed by the common

method, the first operation is sizing and stiffening the wire, which comes from the drawing mill in an exceedingly soft state, and covered with a considerable thickness of oxidation or scurf, in consequence of its having been heated to redness in annealing. To make this wire sufficiently clean, hard, and of the gauge or size proper for the pin-maker's purpose, it is immersed in a pickle of diluted nitric acid, and afterwards well washed in clean water, and dried. It is then wound upon a reel, and one end having been filed so as to pass through the hole of a drawplate, it is fastened to an iron cylinder, made to revolve by a horizontal handle, in the manner described in a preceding volume in the chapter on wire-drawing, and by this means it is drawn from the reel to the cylinder, being reduced by its passage through the plate to the proper size, at the same time it is rendered stiff and bright.

The wire is now to be straightened, by drawing it from the coil in which it lay about the cylinder, and stretching or laying it out in lengths of three or four yards each, upon a board fixed for the purpose. This apparently simple operation is one which requires considerable practice and dexterity in the workman. To effect his object, the man drives seven tacks or bits of strong wire into the surface of a piece of wood attached to the bench and near the reel, as here represented. (*Fig.* 78.) These pegs are arranged in such a manner,

Fig. 78.

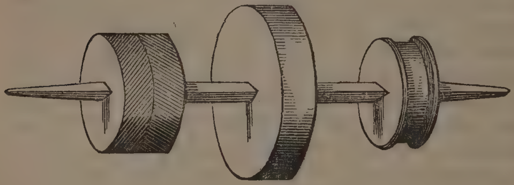


that the wire, on being pulled between them with a pair

of pincers, falls upon the board perfectly straight. These lengths are then cut up with shears into pieces suitable for six pins, allowing a little over: in this state they are ready for pointing.

The pointing is performed by means of a machine called a mill, and which used to be made to revolve by means of a large flywheel, turned by hand: at present, however, in most manufactories, it is connected with steam power. This mill consists of what might be called a circular single-cut file, and a small grindstone of fine grit: the former is a round head of steel about four inches in diameter, two inches across the face, and cut with a double row of teeth, meeting obliquely in the middle. The whole of the machine, including the pulley, and as detached from the frame in which it runs, may be thus represented. (*Fig.* 79.) The workman

Fig. 79.



takes up from one to two dozens, or as many of the lengths of wire as he can manage between his fore-fingers and thumbs: after getting them to lie side by side, and having brought all the ends into a line by pushing them against some straight body, he places them first upon the mill to form the points, and afterwards upon the stone to smooth them, giving to the whole series, by a peculiar action of the fingers, a sort of revolution, by means of which the pointing is effected with a surprising degree of neatness and facility. This operation, from the slovenly manner in which it was performed, used to be accounted particularly deleterious. "Than the men employed in grinding the points of

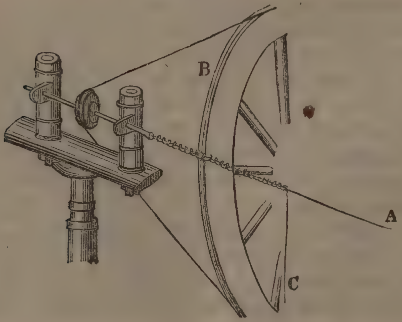
pins," says one account, "more wretched objects are nowhere to be found; and no men would voluntarily endure the sufferings they undergo, together with the forfeiture of their lives in a few years, did not high wages bribe them to the sacrifice. The evil arises from the quantity of brass dust which they inhale into the lungs, which brings on consumption, and which, by getting into their eyes, likewise produces blindness." This appalling description may have had its realisation in some of the old manufactories, where the stones were low, the workmen and their rooms filthy, and the latter ill-ventilated: at present there is certainly no necessity from the employment itself that the men should so suffer; nor do they in respectable establishments. Mr. Elliot's invention, now so generally known to dry-grinders, or the raising of the mill, so that the workman rather *stands before* than *sits over* the stone, alike obviate all serious objections to this work. The writer of this article, on going into the mill room of a Birmingham pin-maker, and seeing two or three clean, good-looking pointers at work, remarked to them that the sallow complexions and *green hair*, said to be peculiar to some of the artizans employed in the trades of the town, were difficult to be met with now: one of the men immediately replied, that if the men who work in brass did present such appearances, they owed the evils to their want of cleanliness. Most of the operations connected with brass or copper-working are reckoned to be, in some degree, injurious to the health of the persons employed. Dr. Thackrah, in a curious work on "The Effects of the Principal Arts, Trades, &c. on Health and Longevity," remarks, that brass-founders suffer from the inhalation of the volatilised metal. In the founding of *yellow* brass, in particular, the evolution of oxide of zinc is very great: the workmen seldom reach forty years of age. According to the same authority, coppersmiths are considerably affected by the fine scales which rise from the imperfectly volatilised metal, and by the fumes of the "spelter," or solder of brass. The men

are generally unhealthy, suffering disorders similar to those of brass-founders. In both cases, however, temperance and cleanliness tend to produce many exceptions to the general result.

The pieces of wire having, by the method above described, been pointed at both ends, the next operation is cutting them up into pins: this is done by placing the ends of a few dozens of them in a small box or measure, against the outer edge of which one of the chaps of a pair of large shears is made to work, as a gauge for cutting them exactly of the required length. The leverage of the arm of the shears is increased by the appendage of an iron stirrup in which the workman places his foot, and by means of which he presently chops the pins off both ends of the little bundles of wire, which are now ready for pointing again, and afterwards cutting up; and these operations are repeated, until at last only two pins, with a little bit between them, remain to be severed. The pins are now ready for heading.

The heading-wire, having been first drawn to a size sufficiently fine for the purpose, is coiled or spun by a very simple operation. A light lathe, or even an ordinary jersey spinning-wheel (*fig.* 80.), is made to give

Fig. 80.

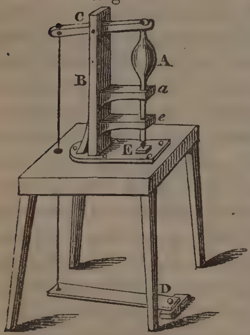


motion to a spindle, in the centre of which is fastened a piece of stiff wire A, called the mould, of the thickness of the pin, and about forty inches in length; to a small projection on the end of the spindle the heading-wire is fastened — both wires passing also through two little loops or staples in a bit of wood, which the operator, generally a female, holds in her left hand to regulate the winding, while, with her right, she turns the wheel B. By this means, revolution being communicated from the spindle to the mould-wire, the heading-wire C, being very soft, is closely wrapped upon it, almost from end to end; and the coil, when completed, easily slides off. A workman then taking six or eight of these coiled pieces in his fingers, cuts them up with a pair of fixed shears into two bouts or three bouts, according to the sort intended. This delicate operation he performs without any gauge except one of his fingers, and with an adroitness which never fails to surprise a stranger: such, indeed, is the delicacy and certainty of touch required by long practice, that without seeing the ends of the wire he can instantly detect the slightest mistake; and at the same time with so great celerity is the work performed that one man will cut 18,000 heads in a day. The heads in this state are annealed, by heating them until red-hot in an iron ladle.

Heading the pins is performed altogether by women and children; and when the work is done in a common manner, they use for the purpose a machine of the most simple construction, and probably differing little, if at all, from that used at the commencement of the trade. The old method of heading consists in gathering upon the shank one of the little coils of wire above described, and then, placing it in a small steel die sunk to half the size of the head, another die similarly sunk is suffered to drop upon it, by which the coil becomes firmly closed upon, and forms the head of the pin, which, during this operation, is held horizontally between the finger and thumb. The upper die is attached to the lower end of a piece of iron having a weight cast

upon it, and two cross-pieces perforated at the ends, so as to slide up and down two upright rods, and thus cause the upper die to drop always exactly over the lower one: this weighted piece is lifted by means of a short lever fixed over the frame, and connected by a string with a treadle below. Heads formed by this method are readily distinguishable by being compressed on the opposite sides; sometimes, so as to form a sharp edge between them; and also by appearing and feeling rough at the top. The "patent heads," which are free from all these defects, are closed upon the pin while in a vertical position; the shank passing through a hole in the centre of the lower die, while the stroke from the upper not only moulds and fastens the head, but renders the top smooth and round. The annexed is a representation of the modern fly for heading pins. (*Fig.* 81.)

Fig. 81.



A is a short square bar of iron, with a metal bulb weight, having the die at the lower end: B is the pillar of cast iron, with its guides *a e*, through which the vertical bar passes; C the lever, connected with the treadle D, for the purpose of raising the bar; E the standing die. To obviate the difficulty which might exist in picking the pin out of this die after the head has been formed, there is in the lower part of it a spring just sufficient to elevate the pin about one third of its length above the surface of the die; this contrivance, while it neither injures the point of the pin nor impedes the stroke, prevents it from dropping through the head, and afterwards renders the removal of the pin perfectly easy. Pins are headed with a globule of tin or type metal; for this method Mr. Harris obtained a patent in 1787: very few pins of this sort,

however, are now to be met with. A pin has very lately been introduced, the head of which is of one piece with the shank: the alleged superiority of this pin is, that the head can never come off; an accident, however, which does not happen to one in a thousand of those of the best kind headed by the common method.

The most ingenious contrivance, however, connected with the manufacture of pins, ever exhibited, is the machinery for which Mr. L. W. Wright, of Wellclose-square, obtained a patent in 1824. It would be impossible, without the aid of numerous figures, to describe, even imperfectly, so complex an engine; but some idea may be formed of the mechanical skill and perfection of workmanship employed, when it is stated that all the diversified and delicate operations which have been already described, as illustrating, in a striking manner, the advantages of an extensive division of labour, may be performed by this machine without any manual assistance whatever. By merely giving a rotatory motion to the principal axle, the wire is drawn off a reel by a pair of pincers, and straightened in its passage between pins: to the axle eight cams are attached, moving an equal number of slides and levers, that work the different parts of the machine. The wire having been drawn down to the length required, the pin is cut off, and caught by two "carriers," which present it to two circular mills in succession. When the pointing is complete, another "carrier" takes it forward to the heading die, out of which, when finished, it is pushed by means of a spring, and drops into a receptacle below. Many strangers from the country visit Mr. Wright's machine as one of the curiosities of the metropolis, and it is really a sight worth seeing. It was lately stated in the public prints, that if the establishment in Wellclose-square were at full work, it would equal the consumption of the whole kingdom, estimated at an expenditure of 16,000,000 pins per day.

When the pins are headed, and otherwise finished, they require to be whitened, which is a superficial sort

of tinning, and is thus performed: — About twenty pounds weight of pins are put into a scouring barrel, and with them about twice that weight of grain tin five or six ounces of red argol or cream of tartar, and three gallons of warm water; the barrel, which is fixed on an axis, is then turned about until the pins appear perfectly clean. They are sometimes after this dipped, a cullender full together, in a solution of blue vitriol, which gives them a cast of copper. They are finally whitened by being placed in layers, alternately with grain tin, in a copper vessel, containing water saturated with cream of tartar, and made to boil for an hour: this operation is repeated once or twice; the pins between each boiling being cast into clean cold water. When sufficiently tinned, they are thrown into hot bran until quite dry; after which the bran is separated by winnowing, and the pins, collected in bowls, are ready for papering. The papers are channelled by a sort of crimping irons, and the pins are taken from the bowl by means of a comb, which places all the heads in one direction, after which they are pushed through the paper with great expedition, a little iron lever being used for this purpose Women and children are employed in this work

CHAP. XVII.

PRECIOUS METALS.

EARLY KNOWLEDGE AND ESTIMATION OF THE PRECIOUS METALS. — THEIR ABUNDANCE AT JERUSALEM — IN GREECE — IN THE ROMISH CHURCHES. — VARIETIES OF GOLD ORE. — GEOGRAPHICAL DISTRIBUTION OF THE PRECIOUS METALS. — GOLD FOUND IN THE BRITISH ISLANDS. — FOREIGN GOLD MINES. — METHODS OF COLLECTING GOLD IN BRAZIL. — DESTRUCTIVE EFFECTS OF GOLD SEEKING ON THE SOIL AND VEGETATION. — SMELTING. — PURIFYING THE GOLD. — INCORRUPTIBILITY OF GOLD. — SILVER. — VARIETIES OF ORE. — DISCOVERIES OF NATIVE SILVER. — AFRICA AND ASIA PRODUCE BUT LITTLE SILVER. — SOUTH AMERICAN SILVER MINES. — SILVER FOUND IN EUROPE — IN GREAT BRITAIN. — ROYAL MINES. — ARGENTIFEROUS LEAD. — METHODS OF EXTRACTING SILVER FROM THE ORE. — EXTRACTING SILVER FROM LEAD. — ELECTRUM. — PLATINUM. — REDUCTION TO THE METALLIC STATE. — ITS PROPERTIES. — USES OF PLATINUM.

By the appellation "precious metals," is commonly understood gold and silver, the two malleable mineral substances which were probably first subjected to the use or adornment of mankind through the agency of fire, and which have been held in supreme estimation from the very earliest era of which we have any records in sacred or profane history, to the present time. The origin of the uses of gold and silver, however, ought, probably, to be referred less to any knowledge or appreciation of the superior purity of these metals as compared with others, than to the fact that they must have presented themselves under circumstances more favourable to the operations of the infant art of metallurgy than either copper or iron; both these latter being found, for the most part, in matrices exceedingly intractable to the smelter. It has been supposed that the

precious metals were first known to mankind in the eastern parts of Asia and in Egypt, — or, perhaps, in the region watered by the Euphrates, which is usually taken to be the Pison of Scripture, the river "that encompasseth the whole land of Havilah, where there is gold; and the gold of that land is good." In the Mosaic history, even from the time of Abraham, the progenitor of the Jewish people, and according to the testimony of profane historians, notices occur of the use of the precious metals, in the first instance, as money passing by weight, and, presently, for the purposes of personal ornament. There are also extant, remains which prove that these metals, especially gold, entered into the fabrication of implements similar to those which are now commonly made of iron or steel. To the circulation of gold and silver in exchange for various commodities, and its application in adorning the persons of its possessors, succeeded its manufacture into sacred and other utensils. It appears from the accounts given in the book of Kings, that in the time of Solomon, the metallic treasures brought by the king's ships from Ophir, and amassed at Jerusalem, were exceedingly great: not only were all the sacred vessels of the Temple of pure gold, but the covering of the House of Lebanon, of the altar, and of the throne, were of the best gold — "none were of silver, for that was nothing accounted of in the days of Solomon," — for, it is emphatically added, "the king made silver to be as stones in Jerusalem."

Herodotus and Diodorus have left accounts, from which we learn that the treasures of gold and silver collected by the sovereigns of Assyria and Persia, were no ways inferior to those possessed by king Solomon; for, notwithstanding that many of the stories of these authors are evidently fabulous, the general fact of the existence of immense treasures in the countries and at the times to which they refer, has never been doubted, but is, indeed, rather corroborated by coincident notices of the subsequent dispersion of these stores. In Greece,

the large amount of the precious metals undoubtedly existing in the several states, appears to have been in the hands of a greater number of individuals. The wealth of Crœsus has passed into a proverb, though no precise account of the extent of his riches has been transmitted to us: he is said, however, at one offering, in the temple of Delphi, to have presented gold amounting to near 3,000,000*l.* sterling of our money. The Roman conquests brought into the treasury of the metropolis enormous levies of metallic money as well as of plate; and, as the empire extended, and drew towards its centre the riches of the then known world, the private fortunes of individuals appear, in many instances, to have swelled to almost incredible sums; so much so, indeed, that Crassus, who certainly seems to have made the most of his money, and who had silver mines of his own, is reported to have said, "that no man could be accounted rich who was not able to maintain an army out of his own revenues." To say nothing of the wealth of individuals, it may be remarked that, when the Romish hierarchy was in the zenith of its splendour, a vast amount of gold and silver was expended in the furniture of the temples of religion. During the middle ages, this munificence of the church stimulated the goldsmiths to undertake the most exquisite works in the precious metals; such, indeed, as, in the opinion of the author of a curious work, entitled "Mores Catholici," where many of them are enumerated, the moderns have been unable to equal or excel. In the very first age of the church we read of golden candlesticks; and, at the close of the third century, there were, in the sacred edifices, many ornaments of gold. A great variety of votive gifts were presented, in which the skill of the artist, however strangely directed, vied with the piety of the donor: some of these were massive, as others were elaborate. For instance, Boëmond, a Christian prince, having been caught during the crusades by the Saracens, and thrown into a dungeon, loaded with chains, made a vow to God that, if, by the

help of his grace, and the intercession of St. Leonard, he should recover his liberty, he would go to the church of that saint at Limoges, and would attach to its altar a chain of silver of the same weight as that with which he was then bound in prison: which vow he accomplished. Celebrated in catholic lore was also the more tasteful gift of the prince of Condé, who, having been long confined as a state prisoner in Vincennes, made an offering to the church of our lady at Loretto of a model of that castle in solid silver. Claude Fleury gives the prodigious value of the different objects presented, such as golden chalices, lamps, censers, and images of our Saviour and saints, besides houses, lands, and money.

Of the places from, and methods by which the ancients obtained and exchanged gold and silver, the extent of the primitive and subsequent mining operations, and the circulation and uses of those materials during the middle ages, — together with accounts of all the more recent transactions relative to this important subject, the reader may find ample and satisfactory details in the interesting work of Mr. Jacob, entitled, "An Historical Enquiry into the Production and Consumption of the Precious Metals." The correctness of some of the statistical and conjectural details of these volumes, has, indeed, been questioned by Mr. M'Culloch; but, whatever differences of opinion may be entertained on matters with reference to which only imperfect data for judgment can be obtained, Mr. Jacob has certainly collected and exhibited, in an attractive and instructive point of view, whatever could bear upon the subject.

Gold is not found mineralised, like other metals, but in what is termed the native state; as, however, the species exhibit some varieties of colour, these have been made the basis of some subdivisions among mineralogists. Gold appears under a great diversity of circumstances, both as to the substances with which it is intermixed, and the appearances which it presents: for instance, it is found massive; disseminated in particles; in films and strings; reticulated and arbores-

cent; and also crystallised in diverse forms, single and in groups. When deposited in rocks or veins, it mingles with several of the earthy fossils, and with many metalliferous masses, as iron and copper pyrites, vitreous silver ores, galena, blende, &c.; but, besides its occurrence in solid bodies, considerable quantities have always been found in alluvial situations, and in the beds of rivers, where it probably first attracted the attention of mankind.

The geographical distribution of the precious metals extends through certain portions of the four quarters of the globe; though the concomitant substances, serving as its matrix in different situations, are too numerous to be particularised here. In Europe, the principal auriferous localities are Hungary, Transylvania, Germany, Sweden, and France. In the last-named country, although considerable quantities have been obtained since the discovery of the mines in 1781, the result, on the whole, has not been such as to lead to a profitable continuance of the operations. Small quantities of the deep yellow variety have occasionally been picked up in Cornwall from the earliest times: and in the reigns of Edward I. and III., there were very considerable works at Combmartin, in Devonshire: between 300 and 400 miners, sent for out of Derbyshire, were employed in them; and the produce was so considerable as to assist the Black Prince in his wars against France. In the reign of Henry III., a copper mine, which was worked at Newlands, in Cumberland, is said to have contained veins of gold as well as of silver. The patent rolls in the Tower record several grants, made by the sovereign to individuals, of privilege to search for gold and silver. In 1390, Richard II. granted to John Younge, refiner, all the gold and silver found in any mine in England, paying to the crown a ninth part, to the church a tenth, and to the lord of the soil a thirteenth part. It may be here mentioned, as indicative of the spirit of occult philosophy which prevailed in those times, that in 1444 a patent was granted to John Cobbe, "that, by

the art of philosophy, he might transform imperfect metals from their own proper nature, and transmute them into gold or silver." Pennant says, "In the reigns of James IV. and V. of Scotland, vast wealth was procured in the lead hills, from the gold washed from the mountains; in the reign of the latter, not less than to the value of 300,000*l.* sterling." In another locality, the Scotch explorers, we are told, found a piece of thirty ounces weight: there were works in several places, but these, if not exhausted, have long been abandoned.* About the year 1796, considerable excitement was produced in Great Britain by the discovery of some large specimens of virgin gold in alluvial soil in the county of Wicklow, in Ireland; and metal to the value of 10,000*l.* was obtained; but the cost of the labour is said to have exceeded that sum. One of the masses weighed twenty-two ounces, and was supposed to have been the largest specimen of native gold ever discovered in Europe; which, however, would not have been correct, if we may credit the accounts of the Scotch specimen mentioned above. In Asia, not to mention other situations, the gold mines of Siberia, those in several parts of India, Japan, the Philippine islands, Sumatra, and Borneo, have long been famous. In Africa, there are numerous localities, described by travellers, and known in the transactions of commerce, as affording gold, chiefly in powder, spangles, or small lumps. Guinea, on the south-west side, is known by the appellation of "Gold Coast;" on account, as is said, of the great quantities of the metal found there. On this coast, in the opinion of some writers, was situated the ancient Ophir, from whence Solomon drew the gold brought by his ships for the royal treasury at Jerusalem. America is exceedingly rich in gold, particularly Brazil,

* An account of a curious manuscript volume, entitled "The Discoverie and Historie of the Gold Mynes in Scotland, written in the Year 1619, by Stephen Atkinson," was printed in 1825, with a preface and appendix of notes, for distribution among the members of the Bannatyne Club, by G. L. Meason, esq., Edinburgh. Some notice of this interesting narrative will be found in the Edinburgh Journal of Science for MDCCCXXVII.

Choco, Chili, and Mexico: many of the rivers, especially those of the Caraccas, are known to be auriferous. From these and other sources, memorable in the history of Spanish cupidity and cruelty, a vast influx of gold has been drawn into Europe within the last three centuries.

The simplest method of obtaining gold, consists in collecting the grains or small particles from the beds of rivers, especially after rains, which bring down fresh matter from the mountains. In some instances, the skins of animals are laid in the water courses, and they retain the metallic particles: it has been supposed that the fable of the "golden fleece," so well known in classical mythology, had reference to this practice. The Brazilians used for this purpose the blankets which, on the opening of the trade to that country some years ago, were, with other equally ill-adapted commodities, sent out by the merchants of Great Britain. The *lavras*, or gold washings of Geraes Minas, or gold district of Brazil, are minutely described by Dr. Walsh, who visited them in 1829. Gold, he says, was first known to exist in the country so early as the year 1543; the Indians made their fishing hooks of it, and from them it was discovered that it was found in the beds of streams, brought down from the mountains. But the first ore found by a white man in that country was in the year 1693: this discovery led to the colonisation of the Minas Geraes, and to all those evils resulting from the "cursed lust of gold," with details of which the history of South America abounds. Dr. Walsh mentions that, at a very early period, "two parties meeting on the banks of the river, where S. José was afterwards built, instead of agreeing in their objects, and pursuing together their operations, set upon each other like famished tigers, impelled by a hunger still more fierce — the *auri sacra fames*. A bloody encounter ensued, in which many were killed on both sides, and the river was from thenceforth called the Rio das Mortes, or the River of Deaths. "The vi-

cinity of this river," proceeds our authority, "every where attests the extensive search for gold formerly pursued here, as it was, for a length of time, considered one of the richest parts of Brazil, from the profusion of the precious metal found on its surface. All the banks of the stream are furrowed out in a most extraordinary manner, so as to be altogether unaccountable to one unacquainted with the cause. The whole of the vegetable mould was washed away, and nothing remained but a red earth, cut into square channels, like troughs, with a narrow ridge interposed between them. Above was conducted a head stream of water, let down through these troughs, which were all on an inclined plane. The lighter parts of the clay were washed away, and the gold remained behind."

The operation of collecting the precious particles is described by Dr. Walsh, as he saw it practised in the works of a gentleman, by whom he had been invited for the purpose. "At the bottom of a very long, shallow, and sloping trench, with a flat floor and perpendicular sides, were laid green grass sods. On some occasions, English blankets have been used; and, on others, hides, with the hair uppermost: but sods were found, from experience, to be the best. At the head of the trench was a large water course. The former collections from the cascalho were placed here, and the water being turned through it, it dissolved the mass, and carried down the whole of it. The lighter parts were borne away, but the heavier subsided into the grass, which entangled the particles of gold; and so it was in the state in which it was first found in the country, when, by a similar process, it was washed down from the auriferous *serras*. The leaves and roots of the grass we saw, were covered with a yellow and black deposit; the first gold dust, the latter esmeril, or oxide of iron, a substance which always accompanies it. Beside the long trench was a pool, in which stood eight or ten negroes, each holding in his hand a round flat dish. These dishes are of three sizes and names; the

first, a gamella, a very spacious bowl, eight or nine feet in circumference; the second, smaller, and called carumbeia; the third, called batea, of a size between both, and in the shape of a flat cone.

"A quantity of the impregnated sods was raised in the gamella by negro boys, and set down before the men in the pool. They took a portion of them, and laying it in the carumbeia, they dipped it into the water, turning it dexterously from side to side, and separating the leaves and fibres of the grass, which were carried away by the water with the lighter parts of the clay, and, in a short time, nothing remained but the gold and esmeril at the bottom, exhibiting clouded shades of black and yellow. When a quantity of this impure mixture was thus collected, it was laid in the batea, and here it was dexterously moved from side to side in a constant ablution of fresh water, till the esmeril also passed off, and the heavier gold dust remained alone in the point of the cone. The whole of this was finally deposited in a large copper skillet, placed over a fire on the spot, and stirred till all the water was evaporated, and nothing remained but dry gold dust, in general of exceedingly minute particles, but frequently appearing in small globules, some as large as a grain of small shot. In this state a magnet was passed through it, to which the particles of iron, still mixed with the gold, adhered; and this was continued till the whole was abstracted. Sometimes a more scientific process is resorted to. The mixture of dust is put into a bowl, and two ounces of mercury added to two pounds of gold and oxide. This mass is worked by the hand into a dough, when the mercury takes up the gold only, which is merely entangled, but not amalgamated with it. It is then put into a cloth, and a portion of the mercury squeezed out; the remainder is set in a brass vessel over a fire, and covered with green leaves, which are removed as they become parched. They exhibit small globules of the mercury on the surface. What remains in the vessel is pure gold."

The quantity collected at this "harvest home" of gold, as the doctor terms it, was about four pounds weight, which, at 4*l.* the ounce, would give 200*l.* sterling; apparently a rich, but, as the writer justly asserts, in reality, a very unprofitable and ruinous mode of farming. "The proprietor had seven or eight blacks, daily employed, for 300 days, collecting the cascalho, whom he first bought, and then fed, clothed, and supported, which left, in the end, but little or no real profit. But by far the most injurious effect was that produced on his farm. As we passed through it," proceeds the traveller, "for several hundred acres every thing green had disappeared, and left behind a red desert, of the most irksome and barren aspect, on which nothing hereafter would be found to grow in any given period, as no new soil is formed, and the old workings appear as recent as those from which the vegetable mould had been washed but yesterday; and thus, in extracting the gold from his farm, the proprietor had extracted along with it every particle of productive riches also." Such is the aspect, in general, of those regions where the search for the precious metals is carried on, whether by washing the diluvial deposits, or by subterranean excavations: to the evil in the latter case has to be added the immense waste of negro life, as the auriferous soils, in most tropical climates, are peculiarly unhealthy. To the sterility produced so generally, it would seem there are some exceptions, for a traveller who, only a few years ago, published an account of South America, says, — "It is usually observed in those countries where great mineral riches exist, that the soil is of a barren and unproductive nature; but Chili affords a striking solitary exception to this rule. Streams, abounding in gold, wander through the most luxuriant corn-fields, and the farmer and the miner hold converse together on their banks."

The dust and grains of gold are smelted in Brazil with a flux of muriate of mercury: the furnaces are heated with charcoal, and the contents of the crucibles

are poured into iron ingot moulds, holding about 32 pounds of the metal. Very pure gold runs in about three hours, but when it contains more foreign admixture, it is proportionately refractory in the furnace, and requires more of the flux.

Gold is afterwards purified by being submitted to the processes of cupellation, parting, and quartation : by the former process the refiner gets quit of every particle of lead or other inferior metallic alloys, and by the latter separates any portion of silver which might remain intermixed with the gold. The cupel, in which the first operation is performed, and which is so called from its resemblance to a little cup, is composed of calcined bones, or in some cases with an intermixture of fern ashes: a vessel formed of these matters, by slightly moistening them, and forming the cupel by means of a mould, not only resists the action of the most vehement fire, but absorbs metallic bodies when changed by heat into a fluid scoria, while it retains them so long as they continue in a metallic state. In a small vessel of this description, placed within side a sort of bent perforated tile made of crucible earth, and surrounded with an intense charcoal fire, the gold, in little buttons, is subjected to the heat. As the heat is continued, and the process goes on, a various-coloured skin, consisting of the scoria of the lead or other metals present, rises to the top, which, liquefying, runs to the sides, and is there absorbed by the cupel. This operation is continued, until a sudden luminous appearance of the mass in fusion, shows that the last remaining portion of inferior alloy has been given out. As, however, the gold may yet retain some portion of silver, which, being nearly as difficult of oxidation as the more precious metal, is not thrown off in the cupel, the mass is next subjected to the process called parting, which consists in reducing it to the state of very thin plates by rolling: these being cut into small pieces, are digested in hot diluted nitric acid, which dissolves the silver, leaving the gold in an undissolved porous mass: this

course is adequate to the attainment of the required degree of purity, when the amount of silver is so considerable in proportion to the gold as thoroughly to expose it to the action of the acid; but when the alloy of silver is very inconsiderable, a previous course is adopted, that of quartation, so called, because the mixture is composed of three parts of silver and one of gold, which on being laminated and digested in the acid, exposes every portion of the gold to the effect of the separating menstruum. In some cases, the two metals are melted together, and sulphur being thrown in combines with the silver, the gold falling to the bottom. Bergman recommended to dissolve the mass in nitro-muriatic acid, by which the silver would be deposited in the form of an insoluble muriate, and the gold would fall in a fine powder by the action of the sulphate of iron.

Gold is the most fixed and apparently incorruptible of all bodies, being almost incapable of oxidation by heat or saline exposure. Boerhaave informs us that an ounce of it was set in the eye of a glass furnace for two months without the loss of a single grain. It yields, however, like all substances, to the solar rays collected and concentrated by the burning glass, not only rising in vapour, but becoming covered with a violet-coloured vitreous oxide. Gold, when refined from all impurities and alloys of inferior metals, is denominated pure, or gold of 24 carats, this being the standard of purity recognised by the mint master and by the dealers in gold. In reality, however, there is no gold so very pure but that it wants about a quarter of a carat of this standard. The carat is divided into $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, and $\frac{1}{32}$. These degrees serve to distinguish the greater or less quantity of alloy therein contained: for instance, gold of 22 carats has two parts of silver, or one part of silver and one of copper and 22 of fine gold: that of 23 carats has half a part, or half a twenty-fourth of each.

Silver, in ore or other of the various forms under which it occurs, is much more widely disseminated than

gold. It differs too from the latter metal in what may be called its geographical habitat: it has been remarked, that the warmer regions of the globe afford the greatest quantity of gold, but the richest repositories of silver are situated either in high latitudes or in elevated regions. The most celebrated silver mines of Europe are in Sweden and Norway, at no great distance from the polar regions; and those which are in warmer latitudes, are almost all situated near the summits of alpine mountains commonly covered with snow, as at Allemont in France, and the mines of Mexico and Peru in the centre of the Cordilleras. The region of the Pasco mines in Peru is the most cheerless imaginable: situated amidst perpetual snow, these mineral dungeons are said to be exceedingly rich in masses of silver, but the insalubrity of the climate, and the constant influx of water, cause them to be worked at a great expense of human life.

Silver is found, 1. in a native metallic state; sometimes in masses of very considerable weight. Jameson mentions that at Schnecberg in Saxony, a rich silver vein was discovered in 1478; and so large a block of native silver cut out, that duke Albert descended into the mine, and used this mass as a table to dine upon. It was afterwards smelted into nearly 40,000 lbs. of silver. Other large masses have been at various times met with by European miners. 2. An ore of silver combined with antimony is not uncommon. 3. Arsenical silver ore. 4. Corneous, or horn silver, so called from some resemblance which the mineral has been supposed to bear to horn. 5. Silver glance, or vitreous silver ore, very common. 6. Black sulphureted silver ore, several varieties. 7. Red silver ore. 8. White silver ore, resembling compact galena. 9. Carbonate of silver, rare. 10. Silver amalgamated with mercury: this is found in a semifluid state in Sweden and some other places. Besides the foregoing, the ores of various other metals, particularly those of lead, are found to be argentiferous in a greater or lesser degree: this is the case

with many of the lead ores of Great Britain, and others in different parts of Europe; indeed, the occurrence of lead entirely free from silver is accounted uncommon. Native silver is not only met with in masses, and variously crystallised,* but it frequently occurs in patches beautifully ramifying from a central deposit, or extending in a filamentous and sometimes entangled web. According to Herrera, the famous silver mines of the Cerro de Potosi in Peru owed their discovery in 1545, to the incidental lighting upon a spray of the latter character: an Indian hunter happening to pull up a shrub, found the roots intertwisted with filaments of pure silver, which turned out to be the shoots of an enormous mass of the metal. The discovery made the spot the centre of a great population; and for some years the production of the mines of Potosi was greater than had been before heard of in the world. Silver never occurs like granular gold, in alluvial soil, or in the beds of rivers.

Africa, which produces abundance of gold, is scarcely known to contain silver mines, though in some parts of the continent, and more especially in the islands, the metal, as derived from other places, has been plentiful enough. An instance of almost unexampled prodigality in the waste of it in a ceremony of barbaric splendour, is related as having occurred on the interment of Radama, the late native king of Madagascar. His majesty expired in a building called, from the immense quantity of this precious metal with which it was plated and studded, the *silver palace;* and the coffin in which he was finally deposited within the tomb, was 8 feet long, 3½ feet deep, and the same in width, composed of silver plates and rivets, to the making of which 12,000 Spanish dollars had been devoted: besides this, 10,000 *hard dollars* were laid in the silver coffin by way of cushion for the corpse. Into the grave was also thrown an immense quantity of rich articles, including the whole superb sideboard of silver plate belonging to the deceased.

Neither is Asia noted for producing silver, though

there are some profitable and well-known mines. The silver is often alloyed with gold in various proportions of from $1\frac{1}{2}$ to 3 per cent. Prodigious quantities of silver, however, have in different ages been drawn by commerce or by conquest into this quarter of the globe. It is believed there are silver mines in China; and argentiferous ores have of late years been discovered in Asiatic Russia.

The most productive silver mines in the world are those of South America; and New Spain, Peru, Mexico, and Potosi, as well as the names of some other places, have become terms almost synonymous with those used to signify precious metal, from the vast quantity of gold, and more especially of silver, which they have long yielded. According to Humboldt, the greater part of the silver extracted by mining in Peru, is found in a species of ore locally called *pacos*, of an earthy appearance: it is a brown oxide of iron, with silver disseminated through its mass in exceedingly minute particles. The ore of Chili is similar; and one vein of it has been mentioned as existing in the Andes, which has been traced more than 90 miles, and is supposed to extend 300 miles, having branches running in the adjoining mountains, some of which are known to be 30 miles in length: it is considered to be the largest metallic vein in the world.

The Indians smelted their precious ores in a very simple and inartificial manner; but since the introduction of European settlers into the new world, the mining operations have in many places been carried on with order and skill; and almost every where, a knowledge of the more successful methods of separating the metal from its matrix obtains. When the Spaniards made the conquest of Peru, they found the natives unacquainted with the use of mercury for amalgamation: they consequently reduced their silver ore by a primitive method, in small portable furnaces or cylindrical tubes of clay, very broad, and pierced with a great number of holes. In these the Indians placed layers of silver ore

galena, and charcoal. After igniting the fuel, a current of air was allowed to have access through the holes, which quickened the fire, and gave it the requisite degree of intensity. The argentiferous masses by this means obtained, were carried by the natives to their own cottages, and there resmelted by means of a charcoal fire, excited by blowing through long copper tubes with the breath, in the manner of an ordinary blowpipe.

In Europe, which so rarely produces gold, the countries where mines of silver are worked, are exceedingly numerous. Among these may be mentioned France, where the produce, however, is inconsiderable: Spain, containing the most ancient silver mines known in Europe, but mostly abandoned since the discovery of America: in Germany, many districts yield silver either in veins, ores, or argentiferous lead: in reference to Bohemia and Hungary, the immense extent of the mining operations have often been celebrated: the working courses are mostly subterranean galleries, one of which is said to be five miles in length. Sweden and Norway contain rich mines of silver, especially the latter country. Enormous masses of native silver have occasionally been found in the Koningsberg mines: travellers mention one piece as weighing 220 lbs.; a trifle, however, as compared with the immense block already noticed as having occurred in Saxony.

Silver has been obtained in considerable quantities in Great Britain, and that from an early period of our history: Cicero, indeed, tells his friend Atticus, that there was not a scruple of silver in the whole island, from which we may perhaps safely infer that the aborigines were not at that time acquainted with the methods of obtaining it, but which methods, it is probable, they would soon learn from their conquerors the Romans. At all events, within about half a century afterwards, Strabo mentions silver as one of the mineral products of Britain; and, according to some authorities, it was obtained in sufficient quantities to have been coined into money in the time of Augustus. This precious metal, however, is

rarely met with in this country in the state of any ore peculiar to itself, but is mostly derived from the lead smelted in Cornwall, Devonshire, Northumberland, and Durham. Every description of our native lead ores is said to contain some portion of silver, and from which it has for ages been extracted. Holinshed tells us that in the reign of Edward I. 1600 pounds weight of silver were obtained in the course of three years from a mine in Devonshire, and which, although called by old writers a silver mine, appears rather to have been a mine of lead that contained silver. Chroniclers record that, in 1239, four plates of silver weighing 14 marks (112 ounces), got out of a mine in the bishopric of Durham, were delivered at Westminster by Robert de Crepping to the proper officer, to be made into images for the king, Henry III. Scotland and Wales formerly produced argentiferous lead ore of considerable richness: gold, as well as lead containing silver were, according to Buchanan, found in Peebleshire, the latter in considerable quantities: the ruins of the ancient works are still pointed out as the "silver holes." In Cardiganshire, the lead mines belonging to sir Hugh Myddleton yielded a sufficiency of silver to enable him to complete that great work for which he is so justly celebrated: and it was from the same mines that the silver minted at Shrewsbury for the supplies of the army of Charles I. was derived, the lead yielding eighty ounces to the ton.

The crown holds an ancient right of claiming, under the designation of "royal mines," all mineral veins containing the precious metals in any considerable quantities, and various difficulties have at times arisen in determining the question as to what proportion of silver in the lead should expose the discovery of ore of certain qualities to such a claim. In a notable trial at Westmister Hall in 1690, it was laid down that the law adjudged every mine to be a "royal mine," the metal of which contained enough of gold or silver to compensate the charges of refining, and the loss of the baser metal

in which they were contained. Lead, to be worth refining, should contain about seven ounces to the ton; but this depends upon the market price of lead, the value of labour, and other circumstances. To put a stop to the litigations which used so frequently to occur under the ill-defined law as it formerly stood, an act was passed in the sixth of William and Mary, entitling the crown to the right of pre-emption of mineral produce on specified terms, including lead ore in a fair merchantable state at 9*l.* the ton, a price certainly much higher than can ordinarily be obtained for the ore of lead in which there is no silver. The existence of this law, while it frees from the apprehension of crown claims upon property as mines royal, tends, at the same time, to make the proprietors of rich mines, like some of those in the northern counties, unwilling to declare what is their annual produce of silver: the mines on the estates of the Beaumont family, however, are known to be eminently rich; so much so, that in 1814 the quantity extracted was said to be 15,000 ounces per annum.

Silver is extracted from its ores, properly so called, either by smelting in a manner similar to that practised with reference to other metals, or by amalgamation,—the former being technically designated the *dry*, and the latter the *wet* method. The processes carried on with chemical exactness at the extensive amalgamation works of Freyberg, the capital of the mining district of Saxony, and where one chief advantage of this mode over smelting is the saving of fuel, are described with scientific minuteness by J. H. Vivian, esq. in the "Annals of Philosophy," vol. xxvii. The first operation at the works is the selection of ores to form a proper mixture, with reference to the quantity of silver and sulphur they contain: this is a most material point. It has been observed, that the amalgamation process succeeds best when the silver produce is about 75 ounces in the ton. The object, therefore, is, by a selection of different ores, to bring the whole as near to this average as can be conveniently effected; at the same time regard being had

to the proportion of sulphur contained in them. This is estimated by the quantity of regule, or sulphuret, found in the ore; which is ascertained by an assay in the crucible. The standard by which they are governed is, that a proper mixture of the different ores gives 35 per cent. of regule; about one half of which may be sulphur. But, as the silver in the Freyberg ores is rarely in the metallic state, at least in any quantity, it becomes necessary to detach it from its combination with sulphur or other substances, before subjecting it to the actual process of amalgamation, as otherwise these substances would prevent its union with the mercury. This is done by adding to the mixture of raw ore 10 per cent. of common salt, by which, during the operation in the furnace that follows, a chemical change is effected. The sulphur becomes acidified, and the acid thus formed, uniting with the base of the salt, forms sulphate of soda; whilst the muriatic acid thus set free, combines with the silver in the ore that was not in the metallic state, and forms muriate of silver.

In this state the ore is subjected to various mechanical operations, with riddles, screens, mills, and sieves, until it is reduced to an impalpable powder. It is then submitted to the action of the mercury, which is the actual process of amalgamation. This is performed in barrels, each about 3 feet in length, and 2½ in diameter, in the centre; and which are so arranged as to revolve on their axis. The mixture or charge in each barrel consists of sifted calcined ore, mercury, metallic iron, and water, in certain proportions. The ore is composed of sulphate of soda, muriate of silver, muriate of iron, and other metals and earthy matters. By the process of amalgamation, the barrels being made to revolve during a period of sixteen or eighteen hours, the muriate of silver becomes decomposed by the action of the iron on its acid, and the silver, thus reduced to the metallic state, combines with the mercury, forming what is termed an amalgam; whilst the sulphate of soda, the muriate of

iron, and other salts, become dissolved in the water. The silver combined with the mercury is then filtered, by which the surplus metal is separated, and a compound remains in the sack, consisting of six parts of mercury and one of silver. This amalgam is subjected to the action of heat in a distilling furnace, by which the mercury is sublimed and the silver remains. The silver is then collected, and melted in a crucible; but as it contains a portion of other metals that were combined with it in the ore, it is afterwards refined in a cupel or testing furnace. Such is a general outline of the process, described with great precision of detail by Mr. Vivian in the work above named.

The method of extracting silver from lead is every where similar in principle; it is very simple, depending upon the different essential properties of the two metals. It is an essential property of lead, when melted in the open air, to lose its metallic appearance, and to burn away into a kind of earth: it is, on the other hand, an essential property of silver, not to burn away, or to lose its metallic appearance, when exposed to the action of the strongest fire in the open air. Hence, when a mass of metal, consisting of lead and silver, is melted in the open air, the lead will be burned to ashes, or into hard masses of a scaly texture, known as litharge, or silver stone, while the silver will sink to the bottom of the vessel in which the mass has been melted. In practice, however, and where the operation is conducted upon a large scale, the silver is extracted from the lead by the oxidation of the latter metal in a reverberatory furnace of a particular construction, the process connected with the use of which has been described as follows: — A shallow vessel, called a cupel, is filled with prepared fern ashes rammed down, and a concavity cut out for the reception of the lead, with an opening on one side for the nozzle of the bellows, through which the air is forcibly driven during the process. The French smelters cover the surface of the ashes with fine hay, upon which they arrange the pieces of lead. When the

fire is lighted, and the lead is in a state of fusion from the reverberation of the flame, the blast from the bellows is made to play forcibly on the surface, and, in a short time, a crust of oxide of lead, or litharge, is formed, and driven off to the side of the cupel opposite to the mouth of the bellows, where a shallow side or aperture is made for it to pass over; another crust of litharge is formed and driven off, and this is repeated till nearly all the lead has thus been scorified and blown aside. The operation continues about forty hours, when the complete separation of the lead is indicated by the appearance of a brilliant lustre on the convex surface of the melted mass in the cupel, which is occasioned by the removal of the last crust of litharge that covered the silver. The French introduce water through a tube into the cupel, to cool the silver rapidly, and prevent its spirting out, which it does sometimes when the refrigeration is gradual, owing, as is supposed, to its tendency to crystallise. The silver thus extracted is not sufficiently pure; it is further refined in a reverberatory furnace, being placed in a cupel lined with bone ashes, as in the cupellation of gold, and exposed to an intense heat, so that the lead which escaped oxidation by the first process, is converted into litharge, and absorbed by the ashes of the cupel.

Native alloys of the precious metals are sometimes met with: an amalgam, consisting of about two parts of mercury and one of silver, is said to occur in Hungary and Sweden. The mineral called electrum, consisting of about 64 per cent. of gold, and 36 of silver, is found in Siberia. An alloy known to mineralogists as auriferous native silver, and composed of gold 28, and silver 72 parts, is procured in Norway

It would be improper in this work wholly to pass over platinum, which, while it has some properties in common with gold and silver, to give it a claim to rank with the precious metals, is not at the same time, unknown in the useful arts; though, hitherto, the quantity obtained has been too small to render its application for

the latter purpose other than confined. Platinum is said never to be found pure: it is mostly brought to us in small grains or scales known by the name of platina, whiter than iron, and very heavy. The principal supply comes from Choco and Santa Fé, in South America; and, till within these ten years, it came from no other quarter: subsequently, some has come from St. Domingo, and from the gold mines in Brazil. In this form, which is now called ore of platinum, it contains, besides some silex, lead, iron, and copper, four new metals, called iridium, osmium, rhodium, and palladium. Russia draws large quantities of this precious metal from mines which are worked in the Ural mountains. The largest mass of native platinum in the Imperial Academy of Mines, at St. Petersburg, in 1830, weighed upwards of ten pounds, Russian weight, but a piece weighing near twenty pounds is said subsequently to have been discovered. Platinum has also been detected in some gray silver ores from Estremadura. Various methods have been adopted to obtain this most valuable metal in a malleable state. Mr. Knight's process, as described in Tilloch's Magazine, was as follows: — The ore is dissolved in nitro-muriatic acid in a glass retort, after which it is precipitated by sal-ammoniac, and the precipitate reduced to the peculiar spongy metallic state, by heating in a crucible. A strong, hollow, inverted cone of crucible earth is then procured, with a corresponding stopper to fit it, made of the same materials, and the point of the latter is cut off about three fourths from the base. The platinum, now in the state of a light yellow powder, is pressed tight into the cone; and, a cover being fixed lightly on it, is placed in the air furnace, and the fire raised, gradually, to a strong white heat. In the mean time the conical stopper, fixed in a pair of iron tongs suitable for the purpose, is brought to a red heat. The cover being then removed from the cone, the tongs, with the heated stopper, are introduced through a hole in the top of the furnace, and pressed, at first gently, on the platinum, at this

time in a state nearly as soft as dough, till it, at length, acquires a more solid consistence. It is then repeatedly struck with the stopper, as hard as the nature of the materials will allow, till it appears to receive no farther impression. The cone is then removed from the furnace, and, being struck lightly with a hammer, the platinum falls out in metallic buttons, from which state it may be drawn, by repeatedly heating and gently hammering, into a bar fit for flatting, drawing into wire, planishing, &c. Count Moussin Poushkin's process, as described in Nicholson's Journal, differs considerably from the foregoing. The count, having reduced the ore to the spongeous metallic state, by methods analogous to those employed by Mr. Knight, adds to one part of the metal so prepared two parts of mercury, and amalgamates the mass in a porphyry mortar. When this amalgam of mercury is made, it is compressed into perforated pieces of wood fitted with cylindric rammers; these being forced down by means of a screw press, separate the redundant mercury from the amalgam, and render it solid. After two or three hours, the wooden cover containing the metal is exposed upon coals, or in a crucible lined with charcoal, and the fire urged to a white heat: the wood burns away, and the platinum is taken out in a very solid state, fit to be forged. In the latter operation, repeated heating is required; and care must be taken, either in hammering or rolling platinum, at the commencement, not to apply too great force till the metal has acquired all its density. The count observes that, when the platinum comes out of the first fire, its dimensions are about two thirteenth parts smaller every way than the original amalgam from the mould: he adds,—"The whole of this operation seems to be governed by the pressure of the atmosphere, and the laws of cohesive attraction; for the air is driven out from between the molecules of the platinum, which, by their solution in mercury, are most probably in their primitive and, consequently, uniform figure. It is very visible, and, at the same time, a very amusing phe-

nomenon to observe (during the process of ignition, which is performed in four or five minutes), how the platinum contracts every way into itself, as if pressed by some external force." The method practised in the Imperial Academy of Mines at St. Petersburg, for rendering platinum malleable, is stated by Mr. Marshall to be as follows: — The ore is dissolved in aqua-regia by means of heat; the solution is, by means of a syphon, drawn off from the black sediment, and contains the muriate of platinum, which, upon the evaporation of the liquid, remains in the form of a mass, showing some tendency to crystallisation. The mass is now dissolved in rain water, and precipitated with sal-ammoniac. This precipitate is a yellowish powder, being a muriate of platinum and ammonia, containing a small portion of iridium. This precipitate is again clean washed and dried, and then, in a cast-iron pot, brought to a red heat, by which means the ammonia and the muriatic acid are volatilised, leaving the platinum of a gray colour and in a metallic state, but still combined with a small portion of iridium. Three pounds of this gray platinum are now ground in an *iron* mortar; it being found, as Mr. Marshall states (contrary to the experience of Dr. Wollaston, who used a *wooden* mortar and pestle), that even the small lumps which are formed by the action of the pestle, thus receiving a certain polish, will, notwithstanding, cohere, or weld perfectly well together. The fine-ground gray powder of platinum is now wrapped in paper, in order to keep it together, inclosed by a thick iron ring, placed upon an anvil, and, by the force of two men, slowly and gently pressed with a powerful screw press into a compact mass. This cake is next subjected to a red heat in a charcoal fire; and, being a second time placed under the action of the press, is very quickly, forcibly, and repeatedly pressed, in order to bring it into as compact and dense a mass as possible; and thus is the platinum brought to a perfectly malleable state. The round cake, or ingot, so formed, is sent to the Imperial Iron Works, near St.

Petersburg, where it is rolled into bars, and that which is intended for coinage sent to the mint, to be converted into ducats of ten roubles each.

Platinum is the heaviest substance in nature; it resembles silver in colour, and is so ductile that it may be beaten out into very thin plates, and drawn into wire so small as the 2000th part of an inch in diameter. It is exceedingly refractory, but may be melted by the blowpipe supplied with hydrogen gas, and by the oxy-hydrogen blowpipe. Like iron, it is capable of being welded; and, like steel, it may be rendered so elastic as to form pendulum springs for watches; and it possesses the still more remarkable property of being capable of union, by welding, with both iron and steel. It may easily be conceived that a metal indestructible as gold, almost as hard as iron, infusible in the hottest furnaces, resisting the action of concentrated acids, and, at the same time, so highly ductile, must be capable of being applied to many useful purposes. In a chemical laboratory it is invaluable, in the form of crucibles, capsules, &c. Melted with copper, it forms an alloy, ductile, susceptible of a high polish, and not tarnishable in the atmosphere; it may also be used for plating and gilding, in the manner of silver and gold. It has almost every thing to recommend it as admirably adapted for the highest description of metallic currency; and, accordingly, in the Russian empire, a coinage of platinum money has been issued.

CHAP. XVIII.

PLATE WORKING.

ANTIQUITY OF THE ART OF SILVERING INFERIOR METALS. — FORMERLY EFFECTED BY AMALGAMATION, HEAT AND FRICTION. — PLATING WITH SILVER UPON COPPER. — FIRST PRACTISED AT SHEFFIELD. — BOLSOVER AND HANCOCK. — PROCESS OF PLATING THE INGOT. — PATENT TRIPLE PLATE. — ROLLING THE METAL. — OPERATIONS IN THE MANUFACTORY. — DIE-SINKING. IMPORTANCE AND EXPENSIVENESS OF NEW PATTERNS. — ANCIENT CANDELABRA. — PIERCE WORKING. — BRAZIERING. — LIGHTING OR ANNEALING. — PLANISHING. — PARABOLIC MIRRORS. — SWAGING AND SPINNING. — FRENCH PLATING. — CANDLESTICK MAKING. — SOLDERING WITH GAS. — ORNAMENTAL EDGES. — CHASING AND EMBOSSING. — VARIOUS STYLES OF FINISHING. — BURNISHING AND FROSTING. — MASSIVE SILVER WARES. — CONSUMPTION OF SILVER. — PRICING OF GOODS. — STATISTICAL NOTICES. — GOLDSMITHS' WORK. — ITS PERFECTION AND VALUE. — ANCIENT AND MODERN WORKS. — ASSAY REGULATIONS. — GOLD TRINKETS. — BIRMINGHAM GOLD. — EASTERN AURIFABERS. — LEAF-GOLD. — LARGE AMOUNT OF THE PRECIOUS METALS EXPENDED IN GILDING. — GOLD WIRE.

In the preceding chapter, we have seen that a knowledge of the methods of obtaining the precious metals, and of fabricating them into a variety of utensils, obtained from the remotest antiquity. We now come to describe some of the processes by means of which the modern manufactures of plate are carried on. As, however, the production of a beautiful and endless class of wares, of which the body is copper, with only a superficial covering of silver, forms a most important branch of our home and export trade, and as the details of working these metals are much the same in respect to each kind, we shall describe them together, first preparing the way by briefly noticing the old-fashioned mode of "silvering," and giving some account of that vastly

superior modern composition which, from the place of its earliest manufacture, has often been called "Sheffield plate."

The art of overlaying, for economy's sake, one metal with another more valuable, is of great antiquity, and was practised both with silver and gold; but the application of the more precious material upon the inferior one, appears, so far as we can judge, always to have been by some method analogous to washing or gilding, or by affixing sheets and foils in some less adhesive manner. Articles so gilt or silvered were from an early period objects of merchandise in this country, and are sometimes noticed in our statutes. In 1403, *temp.* Hen. IV. an act was passed to prevent deception in putting off gilt or plated locks, rings, beads, candlesticks, harness for girdles, chalices, sword pummels, powder boxes, &c. for solid metal; all such workmanship upon copper or latten being prohibited, except ornaments for the church, of which some part was to be left uncovered, to show the copper or brass.

The methods practised in later times, as well upon the Continent as in this country, for silvering copper or brass, were generally those depending upon amalgamation, and what is called French plating. In the former case, pure silver is dissolved in aquafortis, and precipitated with common salt; after which, it is mixed with about six times its weight of sal-ammoniac, sandaver, white vitriol, and a little sublimate: these ingredients are ground into a paste upon a smooth stone with a muller. With this preparation the article to be silvered is rubbed over, and afterwards exposed to a sufficient degree of heat to cause the silver to run, at which instant it must be taken from the fire, and dipped into diluted spirit of salt to clean it. By some such process, it is probable, many of the old metal clock faces were silvered. In the latter case, — French plating, — the practice is to make the metal very clean, and then heat it, until nearly red-hot, when leaf silver is laid on and immediately burnished down, the heat and friction

causing it to adhere perfectly. By this method, successive layers of silver may be applied, to any thickness the work may require. Copper is very readily silvered in a superficial manner, by the following process, which is very analogous to the above, with the exception of the application of heat:—Two parts of silver powder precipitated from a nitric solution of common salt; one part of alum and two parts of cream of tartar: these ingredients are made into a sort of paste with a little water. After cleaning the copper thoroughly, this paste is rubbed upon it by means of the finger covered with soft leather or fine muslin. When the piece is sufficiently whitened, it may be polished by the application of a buff, powdered with calcined hartshorn, or a little Spanish white. In some places it is very common to silver, by means of this preparation, the engraved breast-plates for coffins, the effect of which is very good; and although by no means durable, yet for this purpose the polish will last as long as the occasion for which its appearance is required.

One fact appears indisputable; namely, that by whatever process the old workmen covered copper with silver or gold, the precious metal was always laid on after the articles were formed, and never in such a way as to allow of the laminating, soldering, drawing, and otherwise perfectly working of the combined metals in one substance, as is practised in the manufacture of modern plated articles. An incidental allusion made by Mr. Jacob, though, probably, referring mainly to the old operations of silvering above adverted to, is calculated to convey the notion that the art of plating with silver upon copper, as now practised, originated in the metropolis; or at least, that it was first carried on there to any great extent as a business. "The introduction of plating with silver on copper," he says, "and especially since the manufacture has been removed from London to Birmingham and Sheffield, has caused a vastly increased consumption of silver, especially from about the year 1780, to the present time." The following

respectable authority gives the discovery to the last-named town, to which indeed, it justly belongs:—" The year 1742 is memorable in the history of Sheffield," says Mr. Hunter in his "Hallamshire," "for the introduction of a new manufacture, which has become a formidable rival to the ancient and staple manufactures of the neighbourhood, or, rather, an effective auxiliary in advancing the town of Sheffield to the rank it now holds among the commercial towns of this great empire. It was in that year that Mr. Thomas Bolsover, an ingenious mechanic, when employed to repair the handle of a knife which was composed partly of silver and partly of copper, was struck with the possibility of uniting the two metals, so as to form a cheap substance which should present only an exterior of silver, and which might, therefore, be used in the manufacture of various articles in which silver had been solely employed. He began a manufacture of articles made of this material, but confined himself to buttons, snuff-boxes, and other light and small wares. Like many other first inventors, he probably did not see the full value of his discovery, and it was reserved for another member of the corporation of cutlers of Sheffield, Mr. Joseph Hancock, to show to what other uses the copper plated in this new method might be applied, and how successfully it was possible to imitate the finest and most richly embossed plate. He employed it in the manufacture of candlesticks, teapots, waiters, and most of the old decorations of the sideboard, which, previously to his time, had been formed of wrought silver. The importance of the discovery now began to be fully understood; various companies were formed; workmen were easily procured from among the ingenious mechanics of Sheffield, while the streams in the neighbourhood furnished opportunities of erecting mills for rolling out the metals. Birmingham early obtained a share in this lucrative manufacture; but the honour of the invention belongs to Sheffield, as it is supposed to stand unrivalled in the extent to which the manufacture

is carried, and the elegance and durability of its productions."

The name of one of the individuals mentioned above is associated with an affecting incident. Every reader of English local history has heard of Eyam, in the high peak of Derbyshire, as the village to which the plague was communicated from London in the dreadful year 1666. Among the melancholy memorials of its ravages which strangers usually visit, are several dilapidated grave-stones on a heathy hill a short distance from the village, and amongst them one ruined tomb sacred to the memory of a whole family of the name of Hancock, who, with the exception of one boy, fell victims to the pestilence. The "sad survivor of his fallen house" came to Sheffield, and to him we are indebted for giving the first impetus to a trade arising out of the art of plating on silver. Mr. Rhodes, indeed, in his elegant descriptive work entitled "Peak Scenery," directly attributes to Hancock the discovery of the art itself, though apparently on no sufficient authority: the claim of Mr. Bolsover to having first used it in making buttons, seems to be well founded, and family tradition still points to an old building called "Tudor-House," in one of the garrets of which the cunning loricator prepared in secrecy his metal for the rollers. Mr. Hunter intimates, that the first race of workmen were drawn from the other trades: they were for the most part coppersmiths, and of course well acquainted with the modes of working a material not altered in reality by the circumstance of being overlaid with a precious metal, though requiring many new conditions of skill in its management: their immediate successors earned very large wages, and many of them maintained a respectability of appearance, and took places in society which their descendants have not in every instance neglected to improve. The silversmiths of Sheffield long considered themselves a superior class of workmen, and a generous respect subsisted between them and their employers. Competition and other causes have greatly reduced,

though they have not even yet quite obliterated these honourable distinctions.

The following is the method of preparing the metal for the flatting mill:—A piece of copper, somewhat in the form of a brick, and generally about 12 inches long, 3 inches wide, and $1\frac{1}{2}$ inch thick, is prepared either by cutting it from a bar of that substance of fine copper, or by casting it in an ingot mould as an alloy of about two pounds of brass to twelve pounds of copper. The mass, in either case, is trimmed into a neat form, by filing off the fash or any roughness which might appear; after which it is well and exactly filed on one of its sides with a rasp until it is bright and level, care being taken not to allow any particle of dirt to get upon it, nor even to touch it with the fingers so as to tarnish it. When it has been thus cleaned, a plate of silver, a little less than the surface of the copper, after being made perfectly flat, is scraped with a tool until quite clean on one side, particular care being taken not to soil it with the fingers. This plate, which is of a substance, in proportion to the copper, corresponding to the amount of silver which the sheet of metal is intended ultimately to bear, varies generally from the thickness of a half crown to that of two penny pieces: it is laid upon the piece of copper, so that the bright surfaces of the metals are in contact. Over the silver is placed a piece of sheet-iron, of the same size, brushed over with whiting to prevent its adherence to the mass when heated. The three substances, thus arranged, are well secured by means of small iron binding wire, wrapped round at intervals of an inch, and tightened by twisting with pliers. A little borax ground with water is laid around the silver in the space where its edge approaches that of the copper, after which it is ready for the fire.

A small reverberatory furnace, or low fire-brick oven, heated with hard clean coke, is used by the plater. When the coke is in a state of steady ignition, and the low roof of the oven entirely red-hot, the prepared metal is introduced upon the prongs of a sort of fire-

fork, and placed upon the cokes in the bottom. The door in front is then closed, and the draught increased, until the mass becomes red-hot: in a short time afterwards, the edges of the silver, where the borax was laid, and where it acts as a flux, exhibit a slight degree of fusion, the whole of the superficial plate being nearly in the same state. The ingot must now, by the introduction underneath it of the iron fork above mentioned, be carefully withdrawn, and laid aside to cool. Upon an exact attention to this operation the chief success of the plater depends; for if the metal be not removed almost immediately after the indication of fusion appears at the edges of the silver, it will presently run off into the fire; and if the removal of it, on the other hand, take place a little too soon, the two surfaces will be only partially united, and the work, of course, be good for nothing. But when taken from the fire at that point of temperature which experience indicates, the parts of the materials in contact are found to be in a state of the most perfect incorporation, so that no subsequent operation, however violent, can separate them.

It has already been observed that, although pure copper is mostly used, a metal slightly alloyed with brass is sometimes required: in the former state it is indispensable that fine silver alone be used, whereas, upon the alloy, silver of standard fineness will serve the purpose. This latter mixture is employed, among other purposes, in those cases where a tubular article has to be considerably expanded at the mouth by means of the lathe, an operation to which pure copper will rarely submit without fracture. In 1831, Mr. Roberts of Sheffield obtained a patent for a method of interposing between the two metals a layer of white copper or German silver, of a considerable thickness, the advantage of which in the wear of plated articles so manufactured must appear obvious; it is, however, too hard to admit of being wrought between silver and copper in the ordinary way to any useful extent. Plated metal is reduced into sheets by passing it between steel rollers

in the usual way, taking care to heat or anneal it in the intervals of rolling. If designed for waiters, plateaux, or other articles requiring great breadth, it is rolled both ways, until it is spread out to the proper size; but if only for ordinary purposes, it is generally left narrow in proportion to its length. When the ingot is of about the size previously mentioned, it will be found that the copper will be overspread by the silver to within a little space of the edges; but if the silver be very thick in proportion to the copper, it will be found, in consequence of its greater ductility to spread beyond the inferior material. In the interlaminated metal above mentioned, owing to the hardness of the middle substance, the copper as well as the silver rolls over it on either side, and thus spoils the effect: when the ordinary plating is properly managed, the adhesion of the two metals is rarely found to be injured by any degree of lamination, though there are sometimes little risings or strippings on the surface. The weighing, cutting out, and distributing the metal to the workmen is generally confided to a responsible servant, whose knowledge of the details of every branch of the manufacture enables him to effect the objects of his employers with economy and precision.

The operations carried on in the manufactory of the plate-worker may be distributed into six or seven departments, which are more or less distinct as the establishment is large or otherwise: — 1. Die-sinking; 2. Stamping; 3. Pierce-working; 4. Braziering; 5. Candlestick making; 6. Chasing and embossing: to these may be added, 7. Burnishing.

Die-cutting is a most important affair in the manufacture of plate; and it is that upon which the success and celebrity of many modern works depend. It is, at the same time, the most expensive branch of the business; so much so, indeed, as to place the production of the various articles which are usually exhibited in the show-rooms of respectable houses quite beyond the reach of ordinary competition. The dies of the silversmith, as

well as those of the brass stamper, are required to be made for the most part of steel; and at the same time they must be executed in a much finer manner. As, however, the metal is often very thin, and always soft, the dies are rarely hardened; notwithstanding which, they will last a very long time. The method of cutting steel dies has been described in a preceding chapter. Some few of them used in the manufacture of large dishes and covers, will serve when of cast metal; there being in the articles no sharp work to strike up: but when the designs are deep and delicate, the dies must be of the most exquisitely finished description; for while ornaments in brass, or even in silver, if stamped in a coarse die, might be generally got up by brushing, at the expense of a certain part of their sharpness, to this loss in the plated article would have to be added the risk of exposing the copper. In stamping, when the material is very thin, or the figure deep, particular care, and the frequent repetition of gentle blows, are required, especially at the beginning. The safety of the article during stamping is likewise greatly increased by placing it between two pieces of copper of the same substance; these forces, as they are called, are, along with the matters being stamped, repeatedly lighted over a charcoal fire; and sometimes, when the plate is strong, it is stamped in a red-hot state. Some notion of the expense incurred in dies may be acquired from the fact, that sets for a candlestick which sells for about three guineas the pair, often cost upwards of *50l.*; and if the candlestick have branches, from seventy to one hundred guineas. Nor is there even in the latter case a separate die for every part; as it will be obvious to any person looking at the finished article, that many of the embossed portions of a branched candlestick are duplicates. The parts are, however, more numerous than would be supposed; and an ordinary plated bed candlestick, with extinguisher, is often made up of more than twenty pieces. It must not, however, be supposed, that the dies, even for expensive articles, are always paid for on

terms like these: there is a shallow, showy kind of work, calculated to impose upon the unpractised, the expense of which bears no proportion to that which is produced from dies of the best workmen.

Ancient candelabra were made of gold, or silver, or bronze. In Cicero we have an account of a candelabrum for the temple of Jupiter Capitolinus at Rome, of vast magnitude, executed by the first artists, and profusely adorned with gems. The general form was that of a column, the top varying in breadth, as it was intended for a brazier or a lamp. Cicero asserts that there was hardly a house in Sicily, in his time, without candelabra of silver. Tarentum, and the isle of Ægina, according to Pliny, were considered by the Romans as the most celebrated manufactories of candelabra, and, as we may infer, of other like articles. Those made at the former place were esteemed for the elegance of their external form, and those of the latter for their finished workmanship. Pliny reproaches an opulent Roman lady with having given 50,000 sesterces for a candelabrum, which was the joint production of these celebrated manufactories.

It will be obvious that a good deal of the comparative success of a plate establishment must depend upon the taste and spirit employed in the dies; and as fashions are constantly fluctuating, it is the object of the principal to obtain and retain as much originality as possible in this department. A new article or ornament, however, no sooner makes its appearance in the market in silver, than it is copied by the plater, and from the latter by the Britannia metal worker; and there have not been wanting instances in which much less honourable artifices have been resorted to in order to obtain fac-similes of patterns, even before publication by the original deviser,—the very nature of a die rendering it the most convenient thing in the world to copy almost in an instant.*

* Persons who have visited either the British Museum, or the various collections of antiquities abroad, will have observed how extensively the

Pierce-working is that branch of the business which relates to the fabrication of articles, the body part of which has been perforated with punches at the fly-press. This style of work, which, for inkstands, snuffer trays, waiters, and baskets, was at one time very fashionable, is at present little in demand.

The brazier is the artificer who, in a general sense, undertakes the work which requires to be fashioned or perfected by hammering and hard soldering; his art is analogous to that of the coppersmith. He is required to be conversant with all the methods of planishing, not flat pieces, but of tubular, swaged, and bellied work of every description. These operations are among the most ingenious of the trade; indeed, the dexterity with which a practised workmen uses his hammer is astonishing. The polished steel head upon which plate is planished is called a stake, and may either have a flat face like an anvil, or be of a columnar or globular form, and bent so as to suit the swelling out and driving in of the parts of teapots, basins, urns, or other articles. These, and many similar productions, are shaped in the first place by means of wooden mallets; spherical wares being also bulged out in part by placing them on a sand bag, and striking with a hammer upon an iron instrument placed inside. Silver and plated articles, after having been a good deal hammered, require to be lighted by being heated red-hot: with the latter substance this operation demands to be performed with great nicety; for if it be not sufficiently heated, it will remain as hard as it was before exposure to the fire; if, on the other hand, it should be exposed but a moment too long to the glowing cinders, the silver will fly off the copper; hence,

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various forms, and especially the raised ornaments of our silver and plated wares, have their counterparts in the designs and workmanship of the ancient artists. Those individuals who may not have had the opportunity of seeing the originals, which are scattered in the various depositories, public or private, throughout Europe, may be gratified by an inspection of the beautiful collection of antique vases, altars, pateræ, tripods, candelabra, &c. etched by Mosses; indeed, this is a book which no plate-worker should be without.

the workmen have taught themselves by experience to judge of the temperature of the metal by the following simple but infallible criterion: — They first black the article all over in the smoke of a lamp, and then holding it over a clear fire of cokes, mark when the fuliginous film burns off; as, at that time, and not before, the proper degree of annealing has taken place.

The planishing hammer for flat work has two round polished steel faces; one slightly convex, and the other flat; the former used in the earlier stage of the work. It will readily be conceived that great care is required in planishing, not only that the strokes be made exactly level to the work, but that they be so distributed and combined as ultimately to present one uniform and even surface, and not a series of indentations. In the earlier era of the manufacture, this end was effected by the application of a vast number of slight strokes with a light hammer, as was practised by the coppersmith; it was afterwards found, that by wrapping a piece of woollen stuff over the face of the large hammer, the marks of the rough planishing were much more easily assimilated: a thin piece of bright copper was subsequently added with increased good effect; and, lastly, a bit of hard polished sheet steel was tied over the hammer's face, a piece of moreen or some such stuff being interposed between them. The advantages derived from this simple contrivance, as to saving of time and perfection of workmanship, are exceedingly great to the silversmith.

The parallel swells in most circular vessels, and the raised edges of salvers, with a variety of regular mouldings, are usually produced by means of swages, in the manner described under tin-plate working. In raising silver, however, and especially plated metal, the face of the swage, as well as the under part, requires to be covered with sheet tin to prevent the instrument from marking the metal at every stroke of the hammer, an evil which is still farther avoided by bringing a weighted cord over the upper swage, to keep it from rebounding

when struck. Although there are few forms into which an expert hammerman cannot mould such tractable metals as silver and copper, and the facility with which others may be stamped will be apparent, yet, as the former method is exceedingly expensive, on account of the time consumed, and the latter in the article of dies, the application of steam power is, in some large concerns, made to supersede to a considerable extent both methods, by what is termed spinning, a process exactly similar to that described by the same appellation in the Britannia metal manufacture. The operation consists in causing a circular piece of sheet metal to revolve in contact with a model chuck of wood or other substance, upon which it is gently and progressively folded down and moulded by means of appropriately formed burnishers.

Should any accident occur to lay bare the copper in any particular spot, or should the working up by the hammer of any latent blister in the metal produce a similar deformity, the workman has a most ingenious remedy, in what is called French plating. Having scraped or scoured the place quite clean, and perhaps matted or roughed it a little with a tool, he places upon it a piece of silver reduced to the thinness of foil, and well cleaned: holding the article over a charcoal fire, and directing the heat to the part to be mended, he suffers it to become just red-hot, upon which he instantly applies a burnisher to the patch, and rubs it for a few minutes, when it will be found to adhere so completely that no subsequent operation of hammering or otherwise will remove it. These foils may be laid upon each other to any thickness; and in fact, certain portions of the surface of almost every description of plated ware intended to be engraved, are so overlaid, and the silver afterwards beaten down into the substance of the body.

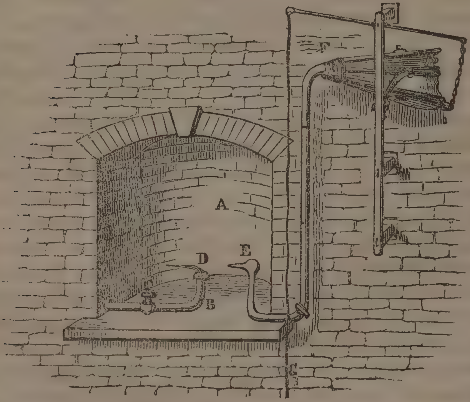
The candlestick maker has nothing to do with planishing, but he has more occasion for the lathe than any other member of the trade, as he uses a variety of tubes, screws, and slides or springs. Candlesticks are

often made with a double pillar, so as to admit of being drawn out in the manner of a telescope, an arrangement of great convenience in their use, as they may thereby be elevated or lowered at pleasure. The tubes are formed in the manner already described in the chapter on lacquered brass-work: they are soldered with a composition consisting of silver alloyed with brass, and reduced to the state of filings. It is laid on by means of a pencil inside the tube, upon a line of triturated borax, as in copper brazing, but in silver plate soldering it is necessary to mix a little sandaver with the borax, to prevent the solder from taking to the iron wire with which the work is wrapped, and which, but for this precaution, would, when stripped away, not only tear the plating off the copper, but be liable to pull even a silver tube into holes. The greatest care is likewise required in soldering tubes or other things of plated metal over a fire where bellows are used; for if the article be not removed on the instant the solder melts, the silver is burnt off, and the naked copper appears; or, as the workmen significantly say, "Alexander shows his face." Accidents like this do not admit of being remedied by the French plating process, described before. The screws used in the slide candlesticks, and for other purposes by the silvermiths, are of brass, over the faces or other outward portions of which a coating of the metal is ingeniously folded at the lathe, by means of tools similar to those used in spinning. By the last-named operation, the nozzle or top of the candlestick is generally formed; the foot, or bottom, if merely round, oval or oblong, is stamped, and is indebted for its perfection to the beauty and goodness of the die. The raised work, consisting of foliages, flowers, scrolls, and all the alto-relievo figures which silver and plated articles exhibit, is mostly stamped in sections, out of metal sufficiently thin to receive an exquisitely sharp impression from the die; these ornaments, after having been filled with soft solder to give them solidity, are attached by means of the soldering iron. This tool has

a copper bit similar to that used by the tin-plate worker, subject to some variations of form for particular purposes.

In the manufacture of silver plate there are many operations of soldering which, on account of the situation or delicacy of the parts, or some other cause, can neither be performed by the iron, nor yet over the fire. In these cases recourse must be had to the use of the blowpipe, and the flame of a large lamp with a great wick, or of a jet of gas. The latter is now commonly used where it can be had, and is found to be the cleanest, readiest, and most economical for the purpose. The subjoined cut will give some idea of the arrangements for soldering by means of gas. A (*fig.* 82.) is

Fig. 82.



the open hearth place under which the operation is performed. B is the tube connected with the gas main, from which it may be shut off by the cock C. The latter tube terminates in a hemispherical head perforated with small holes, like the rose of a common watering can, and through which, as at D, the gas issues. E is

the blowpipe, the air-jet of which is produced by the operation of the small bellows F, through a tube laid for the purpose. A treadle upon the floor at the termination of the string G enables the workman to sustain and regulate the blast with his foot, instead of, as formerly, puffing with his breath; a practice at once injurious and inconvenient in a high degree, and which is now generally laid aside for the bellows, even in manufactories where oil continues to be used. In some very delicate work, the small portable blowpipe is still used in the mouth.

In the manufacture of plated articles of all but the very cheapest kinds, it is common to mount them with edges, and adorn them with ornaments of silver; these, though sometimes exceedingly light and thin, considerably enhance the value, as they ensure the durability of the article as to beauty in a high degree. In 1824, Mr. Roberts, of Sheffield, silver plater, obtained a patent for a new mode of preparing for and putting on these ornamented silver edges. The methods hitherto used with such goods, when the edges were of an indented kind, were to indent by filing the edge of the plated metal on which the ornamented silver edge was to be fitted and soldered, so that it should correspond with the shape of the silver edge; and then, either thinning the metal, or soft soldering a silver thread (to protect it) along the indented edge. The disadvantages of these methods are stated by the patentee to be, first, the raw edge of the copper must be frequently exposed conspicuously to view; if not at first, certainly after a little use; in the second, the thread that is put on must at once attest that the article is a plated and not a silver one. Mr. Roberts's improved method is, after filing the edge of the article to nearly the shape (but somewhat less) of the ornamental indented silver edging, to hard-solder a silver thread of the required strength upon the said edge; and then to flat it with a hammer upon the stake to the breadth and strength required, and so as that the outer edge will extend a

little beyond the ornamented edge, which is then to be soft-soldered on in the usual way. The projecting part of the hard-soldered silver edge which extends beyond the stamped silver one is then to be filed off, and the two edges burnished together till the joining disappears. By this method, it is said, that a workman will scarcely be able to distinguish a plated from a silver article, and that the edges themselves will endure almost as long as solid silver, without the copper becoming at all perceptible. It is, indeed, surprising how long plated articles, defended with silver on the more exposed parts, will last, when carefully used, without wearing through to the copper, and particularly so when not roughly handled in the cleaning.

The reflectors which have for many years been employed in the northern and other lighthouses on our coasts are of this material; namely, copper coated with silver, in the proportion of six ounces of silver to one pound avoirdupois of copper. The metal is rolled at Birmingham or Sheffield, and afterwards, with much labour and great nicety, by a process of hammering, formed to the parabolic curve of a mould made with the utmost precision; these are then polished. These mirrors measure each from twenty-one to twenty-five inches in diameter.

One very ingenious department of the plate-working manufacture consists in what is called chasing or embossing; these terms being used respectively as the work is superficial or deep in the execution. To this practice the gold and silver smiths of antiquity are much indebted for the perfection of their wares; it is, indeed, a process which, next to the art of engraving, and with much greater effect, exhibits in wonderful perfection the designs of the draughtsman. It embodies not merely outline with bold relief, but superadds diversity of texture, surface, and even colour; and some pieces wrought of the precious metals, ornamented in the first style of the art, are of extraordinary value, and justly command universal admiration. Those

who have seen the superb table services of the British sovereign, or those of some of the other princes of Europe, as well as many in private hands, and especially the plate repositories of the celebrated house of Rundle and Bridge on Ludgate Hill, will be able to judge of the truth of these remarks. The method of performing the work is very simple as to the details. The article being finished from the brazier, the design is in the first place delineated upon it in a very slight way, or, if it be not original, by means of red chalk and tracing paper, as is done by the engravers. The work, if at all hollow, as a teapot or a mug, and if the figures are to project considerably, is held upon a sand-bag, and the body of the design is bulged from the inside by the application of a hammer upon a knobbed rod called a snarling iron; the vessel is then filled with a composition of pitch and ashes from the grate, and rested upon the sand-bag during the operation on the outside where the work is perfected. If it be a salver, or other flat article, it is embedded upon a quantity of the composition laid on a board of the proper size, and having a hemispherical under-piece resting in a cavity on the work-bench, by which contrivance it is readily turned about by the chaser, so as to suit his convenience. The lines are then sunk by striking down upon and indenting the metal with little blunt steel punches of shapes adapted to the figure. It would surprise a stranger to see with what facility a workman, by means of a small hammer, and about a score of simple tools, will bring up in bold relief the most elaborate designs.

When the articles are finished in all their parts, the edges dressed, the ornaments soldered on, and the chased or embossed work executed, they are boiled in a lixivium of pearl ashes, to take away the rosin or grease which may remain attached; after which, the raised parts are got up by dry brushing with a mixture of rouge and whiting, and finally by burnishing. The burnishing of plate is an operation to which it is indebted for that rich lustrous appearance so peculiar to the

precious metals when thus got up. The burnishes comprise those of steel and those of blood-stone, the latter fixed by means of cement in ferrules attached to the hafts: they are of various forms, suited to the purposes for which they may be required. In burnishing (which is generally performed by women), the first process is to touch the article over with a little brown soap and water, to counteract any greasiness, and then they apply a rough stone burnish, called rough only as being less exquisitely polished than the others; it obliterates any scratches which may exist, and, as it were, lays the ground: this is followed by a steel tool, then comes the middle stone, and lastly the fine stone is used. These tools are occasionally dipped, during the using, in water in which a little white soap has been dissolved. The articles are finally wiped up with pieces of soft chamois leather. Silver vessels are often gilt inside, and even the copper of plated ones is generally so covered. This operation is performed by laying on a coating of the amalgam prepared as for button gilding, and then dissipating the mercury by exposure to a moderate heat, after which the surface is burnished as above described. The gilding, however, is generally applied at an early stage of the manufacture of the goods, mostly after all the hard soldering has been done; the feet, handles, and ornaments being attached afterwards by brasing the iron: for while the gold would suffer by exposure to a heat sufficiently intense to fuse hard solder, the gilding, on the other hand, requires a temperature more than sufficient to melt off any parts united by a mixture of lead and tin.

In some silver articles there are parts, particularly representations of the human figure, and also animals, which are exhibited in matted or dead work, of a fine white ground, and producing a pleasing effect in contrast with the burnished portions. This effect is produced by covering the subject with a coat of pulverised charcoal and saltpetre, and often heating it until red hot over a charcoal fire, quenching it in a pickle of *sal*

enixon. Sometimes the first operation will be sufficient: but if not, the operation must be repeated, until the fine white ground is produced. In some of the very rich and massy pieces of plate, the figures, instead of being stamped and embossed in sheet metal, are cast from designs modelled expressly by celebrated artists in wax, and copied in plaster of Paris. The London gold and silver smiths sometimes employ first-rate talent in this way.

In the seventeenth century the taste for massive silver tankards and cups was at its height, and this taste extended even to the taverns; so much so, indeed, that in 1696, the use of silver plate (spoons excepted) was prohibited in public houses, in which it was then much used both in town and country; insomuch that we are told one alehouse, near the Royal Exchange, in London, had to the value of 500*l.* in silver tankards, &c.

The making of silver ladles, spoons, forks, sugar nippers, &c. is generally carried on by persons as an entirely independent branch of trade, and mostly in London. This is an important department of the business of the general silversmith; less, however, on account of the beauty of the articles as compared with many others, than from the large amount of metal consumed in their manufacture. The silver table spoons which immediately succeeded those of pewter were very flimsy and light in comparison of those now generally made. "The introduction of tea," says Mr. Jacob, "but especially the extensive preference which it gradually received, till it has become the daily fare of almost the whole community, had an influence on the consumption of silver for small spoons. They were scarcely known in the previous reign, but multiplied in the reign of Anne, and have gone on increasing from that time to the present, when they may be counted by millions, perhaps by hundreds of millions." The same authority informs us that the silver used in modern forks and spoons forms the mode in which one half of that metal consumed in England is applied. These articles are

wrought upon the anvil, in the manner of steel wares, or, in some sorts, pierced out of sheets by means of the fly, and afterwards fashioned by striking in bosses and filing. They are known in the shops according to the style of the handles, as plain, fiddle-shaped, and king's pattern; the embossed work on the latter description being produced by squeezing them when red hot between figured steel dies by means of a Bramah's press. They are got up by brushing and buffing with oil and rottenstone. These articles, which are almost exclusively formed by manual labour, and in which the intrinsic value of the material constitutes so large a portion of the ultimate cost, could only be sold at the usual prices in consequence of the perfection attained in the art, by men exclusively devoted to this particular branch. The metropolitan makers long enjoyed the prerogative of using a somewhat lower value of silver as standard, which no longer exists.

In the wholesale price of gold and silver plate, the workman's wages, and the manufacturer's profit, are combined in a single item, always entered as "fashion:" for instance, a dozen of silver tea spoons intended to sell for 3*l.* would be invoiced thus — "silver, 2*l.* 6*s.* 6*d.*; duty, 1*s.* 6*d.*; fashion, 12*s.*" Of course, while the value of the material and duty are in all cases according to the weight of the article and the current price of silver, the sum charged as fashion will vary exceedingly, according to the quantity and quality of workmanship expended. The difference between the price of plated and silver goods is commonly as that between the value of the silver, including the assay charge, and the selling price; so that a plated toast rack which is sold for a guinea is reckoned to be equal in appearance to a silver one upon which that sum is charged for fashion.

From a parliamentary return ordered in 1832, it appears that the gold watch cases stamped at Goldsmiths' Hall in the preceding year amounted to 9,136. The silver watch cases stamped in the same year amounted

to 55,991. In 1804, the whole duty paid on the fabrication of plate amounted but to 5000*l.*; whereas in 1831 it amounted to 105,000*l.*, and this, too, when the duty on silver had been increased from 1*s.* 3*d.* to 1*s.* 8*d.* per ounce, and on gold from 16*s.* to 17*s.* 8*d.* The French manufacturers produce a large amount of plate in articles of a light, cheap, but often elegant description. In a work entitled "Statistics of France," published in London in 1832, the author says, "With respect to the precious metals, we find that the manufactures of the articles in gold and silver had increased from 1818 to 1826, from 20,000,000 to 40,000,000. In the former year, the quantity employed in table services, &c. and jewellery, was as follows: —

	Gold	- -	16,170 rectagrammes.
	Silver	- -	381,134
In 1825,	Gold	- -	41,078
	Silver	- -	696,075

It is estimated," proceeds this authority, "that 150,000 watches are annually made in France, and about 200,000 are finished only, the movements of which are made in Switzerland, chiefly of gold, silver being out of fashion; and 350,000 clocks, in bronze, gilt, or alabaster cases. Few families make use of any but silver spoons and forks at their tables, nor are any other seen at coffee houses and restaurateurs. This increase in the employment of gold and silver will not appear out of proportion with the increase of gold and silver smiths during the same period, which was from 8000 to 11,000."

The making of gold plate differs scarcely at all, from the manufacture of wares of silver, except in the originality and richness of the designs; and hence the talents of first-rate artists, both as draughtsmen and modellers, are called into requisition and patronised by the goldsmith. Vessels of gold, on account of the intrinsic value of the material, are generally fabricated from unique models, a circumstance which greatly enhances their preciousness; so that repetitions of the

same pattern from steel dies, as practised almost universally in the working of silver, are by no means common, especially when the pieces are large. Formerly, by the term "goldsmith" was understood an individual of a class more nearly resembling the bankers than the plate-workers of the present day; as it was through the hands of these "Lombards" that sovereigns and their opulent subjects transacted pecuniary business with one another. And as, during the middle ages especially, sovereigns and great men were almost the only classes of society in Europe who could indulge in the luxury of golden ornaments, so the few artists who were employed in ministering to this taste were persons of importance—generally, indeed, eminent sculptors or engravers. Benvenuto Cellini, the celebrated Tuscan aurifaber, afforded in his own person a striking illustration of this fact; and the negotiations between this irascible genius and the reigning pope, relative to the making of a gold button for his holiness, are detailed in the amusing auto-biographical memoir of Cellini, with an air of consequence, that could hardly have been surpassed had the stability of the papacy rested (as he evidently considered the credit of the pope did) upon the employment of a goldsmith.

The goldsmiths of this country had considerable reputation in the middle ages. Anketil, a monk of St. Albans, about the beginning of the 12th century, was so famous for his works in gold, silver, gilding, and jewellery, that he was invited by the king of Denmark to superintend his works in gold, and to be his banker or money changer. A pair of candlesticks made of silver and gold, and presented by Robert, abbot of St. Albans, to pope Adrian IV. were so much esteemed for their exquisite workmanship, that they were consecrated to St. Peter; and were the principal means of obtaining high ecclesiastical distinctions for the abbey. According to Muratori, the English works in gold and silver were famous so early as the eighth century, even in Italy.

Allusion has been already made to the large amount

of the precious metals laid up in the churches during the middle ages, in the form of images, sacred vessels, and votive gifts: many of the latter, however odd in their designs, were certainly, no less than the former, calculated to call into exercise the ingenuity of the artists, who spared neither time nor toil in the execution of works, with the objects of which in their minds, as well as in the minds of their patrons, was associated a religious profession. Suger placed in the church of St. Denis a golden crucifix weighing eight marks, and besides the value of the gold and enamel, there were in it pearls and precious stones: two years were required to finish it, though seven of the most skilful artists who had come from foreign countries were occupied on it day and night. The collar of the golden fleece which the emperor Charles V. used to wear, and which is a chain of gold with twelve medallions, presenting the twelve stages of the passion, is a work of such beauty, "that it is doubtful," says the author of Mores Catholici, "whether any artist, goldsmith, or engraver of the present day would be capable of executing it."

The goldsmiths' company of London have enjoyed a royal charter since the year 1392. Besides the master and other officers, there is an assay master, or "touch warden," appointed to survey, assay, and mark all works in the precious metals, in order that the public may not be defrauded. The working goldsmiths of London, as well as those of Paris, formerly carried on their operations in shops open to the street, in order to lessen the chances of their fraudulently evading the corporate inspection and government duties of their works. There is an assay master of the mint, called also the king's assay master, an officer entrusted with the care of making, on the part of the crown, true touch and assay of the gold and silver brought to him, and giving a just report of the goodness or badness thereof. Plate is not accounted gold or silver, nor legally sold as such, unless of standard purity, which is ascertained by cutting or scraping off a small portion of the metal and trying it

by the fire: if found pure, the assay officer stamps the article, and its integrity is admitted accordingly. The duty on wrought gold is seventeen shillings per ounce, and on silver one shilling and sixpence per ounce. Silver articles are generally marked; but of those passed off for gold with the public generally, comparatively a small proportion pays the duty, except wedding rings and some watch cases.

The terms "molten" and "beaten" gold, used by writers of antiquity to denote such works as were executed by the process of casting or hammering respectively, are still applied occasionally. Articles are very rarely, however, cast in gold, owing to the great shrinking which takes place on the cooling of the metal in the mould, in consequence of which it is difficult to obtain that sharpness of impression, so conspicuous in many figures copied from models by this method in most other metals. Although to the use of the hammer, gold plate is, in general, indebted for the form it assumes, and the perfection of all its details of beauty, the labour of the artist has been much abridged by the modern invention of steel rollers, by means of which the ingot is reduced into sheets of whatever thickness or size the work may require. This method of laminating the metal must be of great importance in the making of large articles, where otherwise the cost of workmanship would be greatly enhanced. Ingenuity bestowed upon the fabrication of vessels and ornaments of gold on a large and original scale, is, and ought to be, estimated highly; for, next to statuary and painting, the goldsmith's art, in its noblest exercise, is not demanded to minister to public taste so much as to adorn the sideboards of the great, and even to embody the complimentary munificence of princes. The names of Rundle and Bridge have already been mentioned. The patronage bestowed by this house upon the artificers in the precious metals can only be conceived by those who have some knowledge of the alleged pecuniary amount of their transactions. Of

the value of certain works of this description, some idea may be formed from the fact, that the service of plate presented from Portugal to the duke of Wellington cost, according to the public prints, about 85,000*l.* for the metals, and a like sum for the workmanship.

An amazing variety of small articles are manufactured of what is called, from the place where they are made, "Birmingham gold;" but into the material of which, in reality, sometimes a particle of gold does not enter, as, indeed, the price at which they are sold might lead us to conclude. There are some better sorts of trinkets, however, which consist either of gold alloyed in various degrees, or of some metal plated with it. In the latter style, the beauty of the article is fully equal to that of solid gold; and for seals, brooches, and innumerable other exquisite toys, not of large surface or exposed to much friction, the material answers well, and wears a long time. It was proposed some time ago, by a member of government, to introduce a bill into parliament, to prohibit the manufacture of jewellery from any but gold of fixed standard. The representation of some extensive jewellers, who declared that the measure would be productive of great distress to the trade, without previous consideration of the best means of bringing about the change, has caused a temporary abandonment of the measure. The enactment proposed would make it a serious offence to manufacture gold of less value than 2*l.* 17*s.* 6*d.* per ounce, which must, of course, be stamped. The stamp for what is now called standard gold, but which jewellers are not compelled to use, except for watch cases, will be the same as it is now. In this way, as in France, where all gold articles are stamped, the purchaser of manufactured gold will, on weighing an article, ascertain its *intrinsic* worth, and how much is paid for what is called the *fashion* of the thing. At present, all depends on the conscience of the manufacturer. Gold which does not cost 15*s.* per ounce may be made to look as well to the eye as gold that is worth 3*l.*

Fashion fluctuates as to the colour of gold, the preference being at one time for pale, and at another for red, articles. The beautiful yellow colour so peculiar to pure gold is rendered paler by fusion with borax; but this may be prevented by admixture with nitre, or sal ammoniac: on the other hand, the colour is heightened by an alloy of copper. In various parts of the world where gold is known, and small wares of beautiful workmanship are sometimes fabricated, the artists are often exceedingly little indebted to any kind of machinery, a surprising degree of manual dexterity being exercised by them. This is more especially the case among the people of the East, where idols, trinkets, and even plate for domestic purposes, attest the ingenuity of the artificer, aided, as he is commonly seen to be, with but few tools of any kind. George Bennet, Esq. who went out about ten years ago with the Rev. D. Tyerman, to visit the islands of the South Seas, under the auspices of the London Missionary Society, wore about his neck, on his return to this country, a handsome gold chain, which had been manufactured in his presence, while at Madagascar, out of a couple of Spanish doubloons. The process of fabrication, as described by Mr. Bennet to the writer of this notice, was extremely simple, and shows what could be done by manual dexterity by the aid of so few implements. The artist, in the first place, kindled upon the floor of his shed a little fire of charcoal, and having received the two pieces of gold, he put them into a small crucible, which he placed on the fire. The heat was now excited by blowing; the apparatus for which, and the method of its application, were as follows: — Two pieces of bamboo, each about twelve inches in length and less than one inch in diameter, were stuck in the ground near the fire: to these, two sticks were fitted, to act as pistons, while connected by holes at the lower part of the bamboos were fastened smaller reeds to convey the blast from what might be called the main cylinders to the fire. A boy taking hold of one of the sticks in each

hand, and working it up and down in the wooden tube with considerable address, the fire was presently excited to a sufficient degree of intensity to melt the metal, which was now poured into a groove on a piece of wood, so as to form, when cool, a small ingot. When cold, the workman took the gold and hammered it on a little anvil, and then drew it through the holes of a steel plate, by means of a rude bench, having a roller with a rope and a pair of nippers attached: the wire was occasionally lighted during the drawing. When the wire was sufficiently reduced, it was implicated into the exceedingly neat and substantial chain alluded to, with the aid of no other tools than a pair of pliers and an old knife blade.

Besides the quantity of gold directly manufactured into plate for the sideboard, watches, snuff-boxes, chains, and trinkets in general, an immense amount is consumed in the various operations of gilding. Of this portion, spread as it is over such a vast surface, the greater part is ultimately lost as the articles which are overlaid with it perish. The use of gold in this way is of great antiquity, having, it is probable, been first applied in the form of exceedingly thin plates, and presently in leaves sufficiently thin to admit of being attached by means of some adhesive composition.

Of the gold as well as silver, which is used in vast quantities in this state, only a very small proportion finds its way back to the crucible, the remainder being entirely lost to the community. In a state of the arts like that which exists at present, and with the liberal views now entertained in respect of our manufactures, it would probably be as impossible as impolitic to lay under any direct fiscal restrictions the expenditure alluded to. Regulations were, however, occasionally made by our earlier sovereigns to prevent or discourage the consumption of the precious metals in gilding. In a statute of James I., about 1619, it is enacted that "the better to prevent the unnecessary and excessive vent of gold and silver foliate (*i. e.* leaf) within this realm, none such shall from henceforth be wrought or

used in any building, ceiling, wainscot, bedsteads, chairs, stools, clothes, or any other ornament whatsoever; except it be armour or weapons, or in arms or ensigns of honour at funerals, or monuments of the dead."

In the preparation of gold leaf, the metal is first reduced into long thin strips or ribands by means of steel rollers: it is then cut into little pieces, which are beaten on an anvil, and afterwards annealed. One hundred and fifty of these pieces, now an inch square, are laid two together between leaves of vellum about four times that size, and laid twenty thicknesses on the outsides, the whole being inclosed in a parchment envelope. In this state, the mass is beaten with a heavy hammer on a smooth block of marble, till the gold is extended to the size of the vellum, after which the whole is taken out, and the pieces are each cut into four with a knife: the 600 squares thus produced are interlaid as before with pieces of ox-gut prepared in a peculiar manner, and called "gold-beater's skin." The beating is now repeated with a lighter hammer until the leaves have reached the extent of the skin, four inches square, when they are divided into four by a piece of cane cut to an edge. The whole is then divided into four parcels, interlaid with the membrane, and beaten till they are stretched for the third time to the size last mentioned: the French artists sometimes repeat the division and the beating once more. After the last operation, the leaves are carefully laid on a leather cushion, and cut to squares of from three inches to three inches and three-eighths, by means of a sharp-edged frame made of cane. They are then laid in little books of twenty-five leaves each, the paper of which has been burnished smooth, and rubbed with red bole, to prevent their sticking to it. The finest gold used for this purpose has three grains of alloy in the ounce, silver or copper, or both, as the colour may be wanted: the maximum proportion of alloy is twelve grains to the ounce. It is stated, that there are about eighty gold-beaters in London, and perhaps twenty in other places throughout the kingdom; and that two ounces and two pennyweights of gold are delivered by

the master to the workman, who, if very skilful, returns 2000 leaves, or eighty books of gold, together with one ounce and six pennyweights of waste cuttings. Hence the contents of one book weigh 4·8 grains; and as the leaves measure 3·3 inches, the thickness of a leaf is 1-282000dth part of an inch! A gold-beater's hammer has a round head, with a face very smooth, slightly convex, and about four inches in diameter: three hammers of different sizes are used in succession; the first weighs sixteen pounds, the second twelve, and the finishing hammer eleven pounds.

Gold wire is prepared by drawing the metal, first formed into a cylindrical ingot, through a succession of perforations in a steel plate, in the manner practised with wire in general. For wedding rings, and some descriptions of chains and filigree, fine gold is thus reduced; but a great part of what is called gold wire is, in reality, silver gilt or plated with the more precious metal. The wire which is flattened and spun into gold thread for laces, brocades, &c. is thus manufactured, the silver itself being considerably alloyed; and the gold, which ought to be very pure, is attached by burnishing in leaves upon the silver when the latter is heated, by the process already mentioned as French plating. The ductility of the gold in this extension is amazing. Dr. Halley states that six feet in length of the finest gilt wire, before flatting, will counterpoise no more than a grain; and as the gold is not quite 1-57th of the whole, a single grain of gold thus extended will be 345·6 feet long. By flatting, the length of the wire is increased about 1-7th, and its weight is equal to 1-96th of an inch; hence the surface occupied by one grain is equal to 98·7 square inches, with a thickness of 1-490444th of an inch.

Gold, as it is the most malleable and ductile, so it was long considered the most tenacious of metals: more recent experiments, however, have demonstrated that, in tenuity, it is inferior to platinum and silver, and even to copper and iron.

CHAP. XIX.

METAL BUTTONS.

EARLY HISTORY OF THE BUTTON. — GERMAN MANUFACTORY. — DIVERSITY OF FORMS AND MATERIAL. — IMPORTANCE OF THE BUTTON TRADE TO BIRMINGHAM. — BRASS BUTTONS. — PROCESS OF MANUFACTURING. — GILT BUTTONS. — DESCRIPTION OF THE GILDING FURNACE. — MODERN METHOD OF GILDING. — STATUTES CONCERNING GILT AND PLATED BUTTONS. — LIVERY AND OTHER STAMPED BUTTONS. — GREAT VARIETY OF DIES. — GOLDEN GUINEA BUTTONS. — DECLINE OF THE METAL BUTTON TRADE. — ATTEMPT TO REVIVE THE FASHION OF WEARING METAL BUTTONS THROUGH THE EXAMPLE OF ROYALTY.

WE are told by Hutton, the authority already quoted, that the "toy trades," as they are called, first made their appearance in Birmingham, in the beginning of Charles II.'s reign, in an endless variety. "The first in pre-eminence," he proceeds, "is the button. This beautiful ornament appears with infinite variation; and though the original date is rather uncertain, yet we well remember the long coats of our grandfathers covered with half a gross of high tops, and the cloaks of our grandmothers ornamented with a horn button, nearly the size of a crown piece, a watch, or a john-apple, curiously wrought, as having passed through the Birmingham press. Though the common round button keeps on with the steady pace of the day, yet we sometimes see the oval, the square and the pea, the concave and the pyramid, start into existence. In some branches of traffic, the wearer calls loudly for new fashions; but in this, the fashions tread upon each other, and crowd upon the wearer. The consumption of this article is astonishing, and the value, in 1781, was from *3d.* a gross to 140 guineas. In 1818 the art of gilding buttons had arrived at such a degree of refinement in Birmingham, that three pennyworth of gold was made to cover

a gross of buttons: these were sold at a price proportionably low. The experiment has been tried to produce *gilt* buttons *without any gold;* but it was found not to answer, the manufacturer losing more in the consumption than he saved in the material."

Beckmann mentions a button manufactory in Germany where metal buttons, of all patterns, were made annually to the value of 30,000 dollars: the material he supposed to be regulus of cobalt, a product of the blue colour works. It appears that these buttons were made of a composition which had a white silver-like colour, and was susceptible of a high polish.

Diversified as have been the forms and the sizes of the button, these hardly exceed in number the endless variety of materials appropriated in the manufacture of this seemingly insignificant article. To enumerate them all would be nothing less than to make a list of substances as dissimilar to each other as they are various in their application, under the influence of taste, fashion, and ingenuity. Horn, shell, glass, pearl, paper, coal, jet, and precious stones, as well as embroidery and stuff of all sorts, have, at one time or other, been in vogue. And even of metal buttons, the varieties, as to material and style, have been so numerous and are so continually increasing, that a collection of Birmingham buttons would only be less curious than a cabinet of British coins — the resemblance, indeed, being in many respects very striking.

The commonest kinds of metal buttons are those stamped or cast of pewter, and chiefly used in the trimming of military jackets: they are, of course, very soft, but not being intended to bear any stress, but merely to exhibit the number of the regiment, or some other figure, and to be stitched close to the cloth, they answer the purpose well enough.

Previous to the year 1814, upwards of 1000 individuals were employed in Birmingham in the making of a fancy white metal button, cut by an engine: it was a cheap showy article, and almost the entire produce of

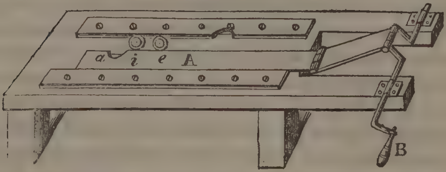
the numerous hands employed was sent to the Continent. A single artisan, well acquainted with the processes of the manufacture, happening to be detained by Buonaparte, stated to the French government his ability to establish a workshop, and produce the button. He was immediately patronised:—the trade presently left Birmingham, and France supplied the markets of Europe. Another article, called the Bath metal drilled shank button, and of which, at one time, 20,000 gross per week were made in Birmingham, was lost in the same way. The particulars of these cases, with some other curious facts illustrative of the facility with which an ingenious workman or two could carry to other countries a knowledge of our manufacturing secrets of this class, may be found in the evidence of Mr. Osler; who was examined, in 1824, before a committee of the house of commons, relative to the policy of allowing the free emigration of artists.

White metal buttons may next be mentioned: they are a composition of brass mixed with various proportions of tin, and are cast in shallow boxes of sand, in numbers of from six dozen to a gross at a time. The shanks, previously formed out of bent wire, are placed in little cavities in the sand, so that the metal when poured into the moulds surrounds and firmly imbeds the shank, with the exception of a small loop. These buttons, which are brittle and sonorous like bell metal, are first turned on both sides in a lathe, and then polished on the face by the successive application of buff-sticks, or flat pieces of wood covered with buffalo skin, and dressed with pounded ganister, bluestone, and rottenstone, mixed up with oil. They are afterwards *whitened*, as it is called, in the manner of pins, by boiling with grain tin and crude tartar, or argol, and lastly brought to a surprising polish by the application of a buff, dressed with the finest pulverised crocus marti, or pure impalpable quick-lime.

In the manufacture of brass buttons, of which the variety is endless, the blanks are pierced out of sheet metal, by means of appropriate beds and punches fitted

to a fly press. The pieces in this state have an exceedingly sharp edge, to correct which, and, at the same time, produce a round, smooth, wire-like edge, they are rolled between two parallel pieces of steel, one moving horizontally past the other, which is fixed, and both of them containing polished grooves on their corresponding faces. To the moveable piece A (*fig.* 83.) a sliding

Fig. 83.



motion is given by means of the handle B. In both the grooved pieces, which are about eighteen inches in length, there are semicircular openings as at *a*, which by corresponding once during each revolution of the handle, admit of the blank *e* being dropped into the grooves, after which it is carried, revolving as it proceeds, between the pieces of steel, till coming to the hole *i*, it drops through into a basket underneath. This operation is performed with amazing celerity by a boy, who drops the blanks into the cavity with his left hand, while he turns the handle with his right. The blanks, having been thus rolled on the edges, are, in the next place, smoothed or planished on the face; for which purpose they are placed in a die under a small stamp, and a smart stroke is given to them by the falling of a polished steel hammer. They are now ready to receive the shanks; these are bent and cut from the wire by a machine contrived for that purpose: one sort of them is manufactured by the aid of a steam engine, which forms them by a single stroke, and produces about eighty in a minute: the shanks are placed upon the buttons with silver, spelter, or soft solder, and detained in their po-

sition by a little cramp of wire, until they are soldered, several at a time. If merely brass buttons of a common sort, they are pickled by immersion in aquafortis — a number together being dipped in a perforated earthen dish: they are then dried, and either turned and burnished at the lathe, or impressed with figure-work by a single stroke with a die at the stamp — the button lying in a boss having a small cavity for the reception of the shank.

The variety of figures struck upon buttons by this means is endless, the work appearing sometimes in relief, as upon coins, and sometimes sunk, as if engraved, according to the execution of the die: in some sorts, indeed, the graver is used in the execution of very fine designs, though this is but rarely the case. Some of this sort of buttons are finished by lacquering; many, by being exposed, after they are polished, to a small degree of heat, by means of which a deeper and more enduring colour is communicated; the remainder are disposed of in the state in which they come from the die.

For gilt buttons, the most brilliant and astonishing produce of the manufacture, a peculiar metal, composed of copper alloyed with a small portion of zinc, or brass mixed with copper, is required: brass of the ordinary composition being unsuitable for gilding. In these the successive operations of piercing out of the sheet, rolling the edges, planishing the surfaces, and soldering on the shanks, are all performed exactly as in the brass buttons. The shanks having been affixed, and the buttons pickled in diluted nitric acid, and afterwards washed and dried, they are rough burnished in the lathe, by means of a hard blood-stone burnisher: this operation brightens and smooths the surface, and by closing the pores of the metal renders it eligible for gilding, — the process of which is now to be described.

The first operation consists in what the workmen term quickening, or preparing the surface of the metal for the amalgam afterwards to be applied: for this purpose, the buttons, in their rough-burnished state,

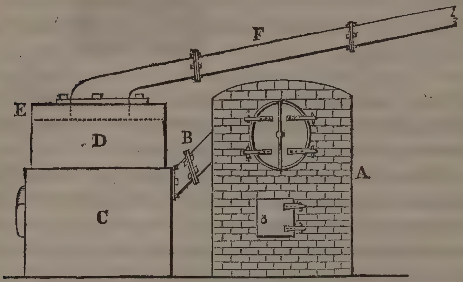
are thrown into a solution of mercury and nitric acid, or "quicksilver water," in which, after having been stirred about with a wisk of small twigs for about five minutes, the silver attaches itself to the copper, and gives to it an exceedingly white appearance. The buttons, on being taken out of this solution, are washed through several changes of water, and when dry are ready for gilding. To form the amalgam, leaf or grain gold is dissolved in quicksilver, in the required proportions, as six or ten to one, by submitting the mixture for a short time, in an iron lade, to a gentle heat, stirring the mass, during the solution of the gold, with an iron rod. It is then poured into cold water, and afterwards put into a piece of wash-leather, which, upon being pressed, allows the superabundant quicksilver to pass through the pores, leaving the mass of a semi-fluid consistency, and fit for use.

In this state the amalgam might be spread upon the prepared buttons singly by means of a brush; but to facilitate the operation, it is dissolved in a small portion of diluted nitric acid, and in this the buttons are stirred about until their surfaces are sufficiently and equally covered by a deposition of the metalliferous ingredients of the menstruum. The next process consists in, what the button-maker calls, drying off, or removing the mercury by volatilisation: this was formerly done by holding the buttons in a sort of shovel over a fire in an open hearth, and occasionally shaking them in a felt cap to equalise the diffusion of the gold, and recover so much of the mercury as the heat caused to stand in drops on the surface of the articles. Not only, however, was the waste of the mercury, by this method, exceedingly great, but the workmen were exposed to such distressing and fatal consequences from inhaling the deleterious fumes, that several individuals, particularly Dr. Lewis, set themselves to devise some means for lessening the terrible evil. The result has been the contrivance of a method, by means of which, the gilding of buttons is rendered nearly innoxious, particularly

when pursued, as is generally the case, only in alternation with other employments.

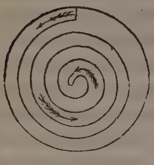
A (*fig.* 84.) is the body of the modern gilding fur-

Fig. 84.



nace, as seen in front, outwardly composed of brickwork, about five high. In the upper part is a strong iron cylinder, fixed in a horizontal position, and surrounded with flues from a fire-place below it. This cylindrical stove, which is four feet long and about two feet wide, is fitted at the mouth with a pair of iron doors, and terminates at the farther end in the pipe B, communicating with the wrought iron vessel C. This vessel, which is about three feet in diameter, and thirty inches deep, is fitted inside with a partition of sheet iron, extending from the bottom to the top, according to the annexed plan (*fig.* 85.). Over this vessel is placed another, D (*fig.* 84.), of similar diameter, but somewhat shallower, open within, but closed at the top by a covering of sheet iron, lying some inches below the margin in the line E, and forming a shallow cistern, which, like the tank below, is filled with water. To the covering of the upper vessel is fixed the metal pipe F, which passes in a direction slightly inclined to the common chimney. *Fig.* 86. is a cylindrical cage com-

Fig. 85.



posed of strips of iron riveted together, and covered with wire net-work: it is connected with an iron rod,

Fig. 86.

or axis, terminating at the near end in a winch handle: it has likewise a small door opening at G, for the introduction of buttons intended to be gilt.

When the buttons have received the amalgam, they are put into this cage, which is then introduced within the stove; the farther end of the axis is inserted in a convenient receptacle, while the other is suspended by means of a chain depending from the roof of the gilding shop. The iron doors are then shut in front, having only a small aperture between them for the rod, so that the stove is completely closed up. The handle is now turned constantly about, and the contents of the cage successively exposed to the heat and shaken together: meanwhile, the fumes raised by the volatilisation of the mercury pass out at the farther end of the stove, and enter the lower tank by the pipe B, traversing the labyrinth in the direction of the darts, (*fig.* 85.) until reaching the centre, what remains of the effluvium passes into the upper vessel, and thence away by the inclined pipe to the chimney. During the progress of the mercurial fumes through the water, condensation takes place, and the metallic particles fall to the bottom of the tank: a still farther refrigeration of the ascending vapour takes place in the upper chamber by means of its head of water, and, finally, most of the remaining atoms are caught in the inclined flue; so that, on the whole, in a large manufactory, quicksilver, to the amount of several scores of pounds yearly, and which used to be suffered to fly away with the smoke, is now recovered by the above method. The buttons, after the gilding, are got up at the lathe with fine blood stone burnishes,

when they receive that rich lustre which cannot be surpassed.

The law takes cognisance of the quality of some kind of buttons: by statute 36 Geo. 3. c. 60. it is enacted, that any person putting false marks on gilt buttons, or any other words except *gilt* or *plated*, or erasing any words except such as express the real quality, incurs a penalty of forfeiting such buttons, and also 5*l.* for twelve dozen or under, and 1*l.* for every twelve dozen above that number. This penalty not to extend to those who mark *double gilt* and *treble gilt*, provided that in the former sort, gold be spread equally upon the upper surface in the proportion of ten grains to the surface of a circle twelve inches in diameter, and in the latter sort, of fifteen grains in the like proportion. In order to ascertain what shall be deemed gilt and plated buttons, gilt buttons shall have gold spread equally upon the surface in the proportion of five grains to the superfices aforesaid; and plated buttons shall be those made out of copper, to which plate silver has been affixed previously to the rolling of the sheet. The gilding of 144 one inch buttons with five grains of gold, shows how small a quantity of that precious metal, when amalgamated with quicksilver, may be spread over a large surface of copper: and yet hundreds of grosses are said to have been tolerably gilt with half that quantity.

Plated buttons are made out of sheet copper covered with silver, in the manner described under plating: it is, however, chiefly in the article of livery buttons, or others having raised heraldic or fanciful devices, letters, monograms, &c. that this material is very extensively used. For this purpose, the metal is very thin, the silver being more or less in proportion to the copper, according to the price: the blanks being pierced out of the sheet, are stamped in steel dies, figured with the impression which is to be communicated to the piece: this, from the comparative thinness and softness of the copper, and the shallowness of the work,

is readily effected by a single fall of the stamp hammer: at the same time, the die is so formed by being cut deeper than the thickness of the metal, that the latter is dished or turned up at the edge all round, so as to admit of being lapped over the body of a foundation button containing the shank. This ingenious operation is performed by means of the fly press, in the following manner: — the plated cover or top, dished as already described, is placed, with the cavity upwards, in a steel bed, exactly turned to receive it, and so hollowed out towards the centre, as not to allow the figured surface to touch the iron: a circular bit of pasteboard is next inserted, and over this the button containing the shank; the boss or punch attached to the press screw, and which is properly hollowed out, is now brought down upon the article, and embracing the circumference of the flange, folds it neatly and firmly over the inner piece, so as to constitute a light, elegant, and unfailing button.

The cutting of the dies is a separate trade, and not only employs a great many hands, but calls into profitable exercise a large amount of operative ingenuity. The designs for buttons, whether fanciful or specific, are generally furnished either by the manufacturer or his customers; and the degree of excellence displayed by the artist employed varies considerably, from the commonest cypher on a pewter button, to heraldic and other designs, the spirit of which approaches very nearly to the exquisite perfection of numismatic die-cutting. Nor, it may be added, would any person at all acquainted with the matter indulge a moment's wonder, should he be told that an individual daily conversant with such kind of work, and at the same time being unprincipled and needy, had been tempted to turn his hand to the felonious execution of matrices similar to those used in striking the coins of the realm. Of the capital invested, and the ingenuity patronised by the Birmingham button makers, an imperfect idea may be formed from the fact that we noticed in the shop of Mr. Hardman, a celebrated manufacturer of that place,

upward of ten thousand double sets of cut steel dies for livery buttons alone.

Filigree buttons, not only of silver but of gold, are sometimes fabricated in very elegant style, either by first piercing the metal and then folding it into various shapes, or by some analogous operation. Buttons made of coins of the precious metals have sometimes been worn by persons of fashion. Ben Jonson's beau would wear —

"Brabant buttons, all my given pieces;"

and Mr. Mellish, formerly of Blyth, and the well-known turf companion of his late majesty when prince of Wales, attracted the curiosity of gazers by appearing on the race-ground at Doncaster, decorated with a profusion of spade-ace guinea buttons!

No metallic ornament worn upon the male dress can surpass in splendour the burnished gilt button; nevertheless, such is the caprice of fashion, that for some years past, the taste for this elegant article has almost altogether given way to the use of buttons wrought over with silk or covered with cloth, so as to be uniform with the garment; though the latter practice is in direct contravention of several statutes for the protection of the metal button trade, the penalties of which have frequently been levied within the last twenty years. The enforcement, however, of sumptuary laws, which are, at the best, exceedingly obnoxious to reprobation, is little likely to be attempted in the present day with any other result than to effect their repeal: accordingly, the make and material of these useful fastenings of the garment are left, as they ought to be, to the taste of the wearer. Soon after the accession of his present majesty to the throne, a deputation of the Birmingham button makers presented a petition, not in the usual way, through the secretary of state, but to the king in person; praying the royal encouragement to their manufactures, very elegant specimens of which they exhibited. The deputation was most graciously received, and the

next day the king, queen, and the princes George of Cumberland and Cambridge answered the petitioners by assurances of doing all in their power to make the wearing of metal buttons general, especially by themselves setting the example. This was done accordingly; but the sovereign example appears to be almost as much a dead letter as the statutory regulations inflicting pecuniary penalties, of from 40*s.* to 5*l.* per dozen, upon the person who shall cover button moulds with the same kind of cloth as the coat.

CHAP. XX.

COINING.

ANTIQUITY OF THE ART OF COINING. — CHARACTERISTICS OF ANCIENT COINS. — MATERIALS OF COINS. — EARLY EUROPEAN MINTS. — LOCAL OR PRIVATE TOKENS. — INTRODUCTION OF AUTHORISED COPPER MONEY. — GOLD AND SILVER BULLION RECEIVED AND ASSAYED AT THE ROYAL MINT. — APPARATUS USED IN CASTING THE INGOTS. — ROLLING AND SIZING THE METAL. — CUTTING OUT THE BLANK PIECES. — SIZING AND PICKLING THE BLANKS. — MILLING THE EDGES. — STRIKING THE IMPRESSIONS ON THE COIN. — APPARATUS FOR SUPPLYING AND REMOVING THE PIECES. — MEDALS. — INSTANCE OF WANT OF CALCULATION. — STAMPING MEDALS. — THOMASON OF BIRMINGHAM. — PRESS FOR STRIKING MEDALLIONS. — MEDAL DIE.

The art of embossing small circular pieces of metal between steel dies, either to circulate as money, or as medals for the commemoration of some person or event, is of high antiquity. Metallic pieces of both these descriptions are found in amazing variety, and often in a state of beautiful preservation, in the cabinets of the curious: sometimes they are met with in turning up the earth, or in other situations where they have lain for centuries. Ancient coins and medals, when genuine, and when their dates, legends, and pictures are legible, not only attest the progress of the numismatic art, but often also tend to educe, connect, or corroborate important facts in history and chronology. Various erudite treatises have been written upon this interesting branch of antiquarian research; and to these works civil and ecclesiastical history have been respectively indebted. The records of our own country owe much to this species of illustration; and with respect to the coinage itself, in whatever light considered, the subject has been voluminously treated upon in the interesting "Annals" of the late Rev. Rogers Ruding.

Although the ancients are allowed to have surpassed the moderns in the exquisite art of gem engraving, they appear to have made comparatively little progress in the apparently proximate branch of die cutting. Hence, notwithstanding that some coined pieces of the early eras of Greece and Rome present bold and striking devices, and, in some instances, heads that are taken for likenesses, the workmanship of the great mass of antique coins admits of no comparison with that displayed in various precious stones, the materials of which, it might have been thought, would have presented difficulties to the artists far greater than those encountered in figuring such a material as steel.

The imperfect execution of ancient coins appears, however, far more striking in connection with what we may presume to have been exceedingly defective apparatus for copying such designs as they might execute. The oldest pieces appear evidently to have been impressed by striking the dies with a hammer, the blank between them being in the first place very imperfectly rounded, and then not only spread out very irregularly, but often struck considerably out of the centre. In some cases, they appear to have been cast; and moulds for this purpose, sometimes containing metal in their cavities, have been discovered in this country. It has been left to modern artists, Italian, French, and English, with more perfect machinery, to produce those splendid series of coins and medals which so justly excite our wonder and admiration.

Most of the metals have at one time or other been used for coins, more particularly pewter, copper, brass, silver, gold, and platinum; the former was coined by king James in Ireland, and the latter has been introduced into the circulating medium of Russia: the other four, however, are most commonly met with in the state of coin.

In most of the modern nations of Europe, there were originally a great number of authorised mints; and to how great an extent this system was carried in Great Britain, may be learned from a perusal of the local histories of the principal towns, as well as from an inspec-

tion of the coins issued therefrom, which are still extant in collections. In England, however, for a considerable period, there has, with great propriety, been only one pubic authorised mint, under the immediate inspection of the executive power; which, while it gives the best security for the absolute uniformity of the medium of exchange, provides, by the liberality of its establishment, against any objection that could be formed to the exclusiveness of its privileges: delivering out without deduction for seignorage, duty, workmanship, or even waste, the full value of all bullion brought in to be coined. To effect this object, the machinery, afterwards described, is of the most powerful and perfect kind.

Notwithstanding this arrangement, there has been a variety of private coinages, for temporary purposes, effected, if not by the connivance, certainly without any immediate interference of government: these have been divided into three classes — the old *tradesman's tokens* of the seventeenth century; the *siege pieces*, as they were called, and other *pledges for money* issued during the civil wars; and lastly, the *copper promissory notes for halfpence, &c.* which preceded the beautiful coinage in that metal, executed for government by the late Mr. Boulton: indeed, the latest specimens of these local copper tokens, although authoritatively suppressed, are scarcely yet quite out of circulation. A few years ago private tokens, ostensibly of silver, and even of gold, were distributed; until happily superseded by the abundant and beautiful coinage of those metals now in use.

Without going farther into the subject, it may be remarked, that gold and silver money was for many centuries the only current coin of this kingdom; and that copper was not issued by authority till some time after the restoration. In consequence of the general extension of trade, and especially of the retail trade, as the bulk of the people increased in wealth and consequence, much inconvenience was found to arise from the want of some pieces of smaller value, to serve as *change* for silver money. For though silver pence, and even

halfpence, were then coined; yet since, as Pinkerton observes, a man might have a dozen or two of them in his purse, and scarcely be able to discover them with a microscope, it was not to be expected that they should ever come into extensive circulation. In this dilemma the device of tokens was hit upon, and eagerly adopted, till every petty tradesman had his pledges for a halfpenny, *payable, in silver, to the bearer, on demand,* at his shop: upon the credit of which it therefore depended, whether they should circulate through one or two streets, a whole town, or to some distance in the country round.

The various inconveniences arising from these tokens, particularly the obvious want of security to the acceptor, from the frequent insufficiency of the issuer, might easily have been obviated by a copper coinage under the authority of government; but to this Elizabeth could never be persuaded. Her successors, James and Charles, issued their respective *farthing tokens;* which, though not declared by proclamation an authoritative tender in payment, yet from the superiority of the security, they in great measure superseded the *private* tokens, till the unhappy end of the latter monarch destroyed the credit of his coins: after which, during the commonwealth, and under Cromwell's usurpation, private presses were again set to work with greater activity than ever; and continued to supply an abundance of halfpence for circulation, till the year 1672, when they were suppressed by proclamation, and a regular coinage of halfpence and farthings, such as those which immediately preceded our present copper money, was issued under the authority of government.

Gold bullion is mostly imported by the Bank of England, and is usually transmitted to the officers of his Majesty's mint in the form of ingots. The metal is tried by the assay master, previous to passing to the manager, and alloy or fine gold placed with it in the melting pot, according as the ingots may happen to be better, or more than in the proportions of twenty-two

carats fine and two carats alloy, which is the English standard for money. The gold is melted in black lead crucibles, in an air furnace about one foot square, and eighteen or twenty inches deep. The fuel consists of clean cokes, first ignited by means of a layer of charcoal, and heaped somewhat above the mouth of the melting pot, which is covered with a sort of muffle: each pot contains an hundred pounds of metal, though sometimes more or less, according to circumstances. When fusion has taken place, the metal is stirred with a rod of similar material with the crucible, in order thoroughly to mix the gold and alloy. The crucible is then withdrawn, by means of tongs, and its contents poured into moulds, the matrices of which yield bars, ten inches long, seven inches wide, and an inch thick. These are assayed; and, when reported of standard quality, they are delivered to the moneyers, to undergo the subsequent operations.

Silver bullion is generally imported in ingots weighing from fifty to sixty pounds troy each. As in the case of gold, the silver brought to the mint is first assayed to ascertain its relative purity, which in the potting is computed to become of the proportions of eleven ounces and two pennyweights fine silver, and eighteen pennyweights alloy, which is the money standard. Silver is melted in very strong cast iron pots in the form of the letter U, and containing from 400 to 450 pounds troy each. As these pots are round, the furnaces are built with circular fire-places, about thirty inches deep, and twenty inches in diameter, having a metal stand or pedestal at the bottom, upon which the pot is placed: the mouth of the pot is covered by a muffle, and cokes are used for fuel, as in the melting of gold. Formerly the melted metal was transferred from the pot to sand moulds, by means of an iron ladle, which was not only a difficult and wasteful method, but by dissipating the alloy in consequence of the stirring of the mass, frequently so refined the silver that the melting had to be repeated. At present, not only are cast iron ingot moulds used, but the pot is at once conveyed from the furnace

by means of a crane and appropriate tackle, and placed in what is called the pouring frame. This last-named contrivance consists of a rectangular structure of iron bars, under which a carriage is made to move along a railway, and upon which carriage are placed the moulds, screwed together in a row: the pot itself is so fixed in connection with a quadrant rack, that by turning a handle it is inclined, and its contents poured into the moulds, each being, for this purpose, brought under the pot in turn, by the slightest movement of a winch handle, which, acting on a rack, advances the carriage along the railway. In the melting house at the Mint, there are eight furnaces, two of these pouring machines, and two cranes for transferring the pots, each crane traversing between four furnaces and an adjacent machine.

The bars of silver having been assayed, and pronounced standard, are in the next place annealed by heating them red-hot, and afterwards passed between rollers, to reduce them to sheets. Gold bars, as taken from the moulds, do not require to undergo this lighting, as they do not show the least tendency to crack on the edges when laminated. The rolling apparatus at the Royal Mint chiefly differs from those already described in these volumes for the flatting of metals, in the beauty and solidity displayed, and the perfect working of all its parts. When the metal, whether gold or silver, has been reduced by rolling nearly to the size or thickness required, it is cut into slips of the breadth of two coins, not by lever shears, but by a contrivance now common among fender-makers, iron and brass-rollers, and others using strong sheet metal, and possessing steam power. The machine for this purpose consists of two hardened steel wheels, or circular cutters, the sides lying in close contact, and the edges overlying each other a little: by placing the flatted ingot upon an iron plate, and against another piece called a guide, and then pushing it along, the cutters, acting in the manner of those used for slitting iron and steel, divide the precious metals into bands or ribands of the breadth

required. For the securing of greater accuracy of size than could be obtained by rolling alone, these slips are afterwards pulled, by means of a pair of nippers and an endless chain, between two steel dies, which operate upon the metal in the manner of the plate or whortle in wire and tube drawing. The attainment of comparative accuracy in the sizing of gold and silver, previously to the stamping, is, as will easily be conceived, an affair of great importance in the moneyer's art, inasmuch as it renders the pieces less liable to that variation in weight, the remedying of which, by any separate process, is so tedious and difficult.

The next operation consists in piercing the blank pieces of a circular form out of the strips of metal prepared as above described. This is done by a fly-press or cutting-out machine, constructed by Boulton and Watt of Birmingham, on the principle of that for which, in 1790, the celebrated Matthew Boulton of the Soho had a patent, and which machine he then applied to the stamping of the fine copper coins manufactured for government. The material parts of the fly itself differ but little from those of the ordinary apparatus known by this name, and used by button-makers and numberless other classes of artizans. Through a stout cast-iron body passes a screw with two or three worms, which cause it to descend rapidly: the lower end of this screw is attached to a square piston, which slides up and down through a guiding box, so as to have great firmness and evenness of motion. To the bottom of this piston is affixed a circular steel punch, exactly the size of the piece to be forced out of the plate, and working, when forced downward, through a hole of corresponding diameter in a steel bed below. There is likewise placed just over this bed a thin iron plate, through which the punch also passes, and which serves, on the rising of the screw after the stroke, to detach the metal from the punch after it has pierced it, and allow of its instant replacement for the succeeding stroke. The chief feature of novelty in the construction of this

press, is the contrivance for communicating revolution to the screw, or, in other words, giving the stroke.

To the upper part of the main screw is fitted a horizontal lever, weighted at one end to give the necessary momentum to the machine, as in the common fly-press. Instead, however, of working the press by alternately pushing back and pulling forward this weighted arm, either by means of a cord or of a depending handle, as in the ordinary method of cutting out sheet metal, there is a vertical spindle attached to the top of the main screw, and made to work steadily by means of a collar at the upper end, in which it is allowed a slight degree of motion upwards and downwards, corresponding to the rising and falling of the screw. Upon the top of this spindle is fixed a bent lever, one end of which terminates in a friction-roller, and to the other end is linked an iron rod: the purpose of these contrivances shall now be explained. Twelve of these cutting-out presses are firmly fixed by means of screws on a stone basement, around a circular room in the Royal Mint, and in the centre of which revolves a large horizontal fly-wheel; and parallel therewith, and on the same upright shaft, another wheel, having on its margin, at considerable intervals, cams or large obtuse cogs. This wheel revolves exactly in the plane of the bent upper lever above described, so that as the cams strike in succession the roller ends of each lever, the latter is pushed back, and thus winding up the main screw, raises the punch thereto attached above the bed, sufficient to allow of the introduction of the strip of metal. The moment the cam has passed, and the lever is at liberty, it swings back to its former position, thus forcing down the screw, and piercing the blank coin out of the metal by the punch in the die. To effect this return motion of the lever-arm with a degree of force sufficient to give the stroke, Mr. Bolton adopted the following ingenious contrivance: — The iron rod mentioned above, as being attached to one end of the lever, is connected, by means of a crank, with a piston working very tightly in an

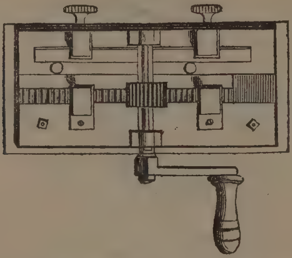
exhausted air-cylinder; so that every time the cam moves the lever on its axis, so as to pull the rod, this piston is forcibly lifted, and a vacuum consequently formed in the lower part of the cylinder; and the moment the cam has passed, the piston is suddenly driven down again by the pressure of the atmosphere. This action takes place exactly upon the same principle as that which is exhibited when a person places his finger upon the perforation in the end of a syringe, and then draws up the plug, which, on being released, is found to fly back with a degree of force corresponding with the diameter of the tube, and the completeness of the vacuum formed within. The rebound of the stroke of the cutting-out press is met by an upright piece of wood, against which the lower, or weighted lever arm, strikes, and rests until the next cam renews the motion.

After the blanks have been cut out by the machine just described, they are in the next place sized, *i. e.* reduced to the standard weight: this is effected by filing such as are too heavy, the light ones as they occur being thrown aside to be remelted. The extreme nicety obtained by the perfect machinery now used in flatting the metal and cutting out the blanks, renders the business of the sizing-room much less tiresome and laborious than it was formerly. When adjusted as to weight, the pieces are annealed by heating them, a number together, in a reverberatory furnace, until they become fully red-hot. They are in the next place pickled, by boiling them in diluted sulphuric acid, out of which they come very clean, and of a beautiful colour. After they have been dried in hot saw-dust, and wiped clean out of it, they are ready for milling on the edges.

The milling-machine, of which *fig.* 87. shows the plan or face, consists of a stout plate of iron attached to the surface of a wooden block, raised to a convenient height for the workman to stand beside it to manage the operation. An axle, having a pinion or cogwheel in the middle, and a winch handle at one end, is fixed across the plate in two upright bearers. This pinion

takes into the teeth of a rack made to slide in a groove

Fig. 87.

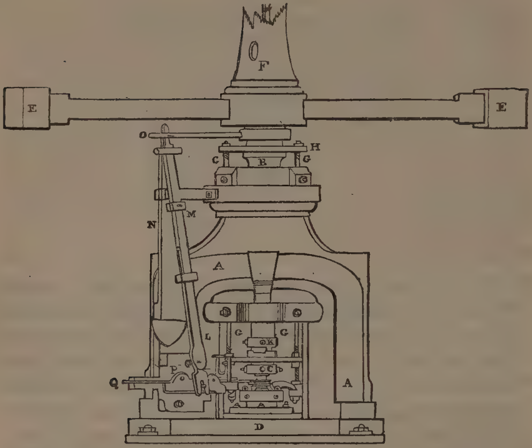


in the direction of the length of the plate, and kept in its position by two over-lying clamp-pieces. Attached to the side of this rack is a steel bar or ruler, finely cut across the edge; and opposite to it, at the distance of the diameter of a coin, lies an immoveable bar, similarly cut on the adjacent face. This bar is kept fast down in its position by means of two screw-clamps, which may be exchanged for others, and the bar removed nearer to or set farther from the sliding one parallel to it, — thus adapting the machine to the size of the money to be milled. Two pieces, as represented in the cut, are supplied at once by a boy, while a man, by means of half a revolution of the handle, rolls the pieces between the two rulers, when they receive from the pressure that peculiar indentation of edge which we see in almost all our gold and silver coins. The dexterity with which, in consequence of much practice, a boy supplies and removes the blanks, in unison with the celerity of the machine, is very striking to a looker-on. The object of this milling is to prevent the coins from being so easily clipped or filed on the edges with impunity; tricks to which money, previously to this protection, was very frequently liable.

Fig. 88. is a front elevation of one of the presses at the Royal Mint by which the impressions are made at

once on both sides of a piece of coin. A A is the

Fig. 88.



strong cast-iron body or frame, firmly fixed with large nuts and screws to a solid stone basement. The upper part contains a brass box, through which works perpendicularly the main screw B, the worms of which are, however, so inclosed within the metal as not to be seen on the outside. One of the steel dies which strike the coin is fixed, by means of four side screws, in the box C, at the lower end of the main screw: the other die is fixed in a box resting on the bed of the press at D. The loaded lever-arms E E are calculated from their momentum to communicate a sufficient force to the screw, in its descent, to give the requisite impression to a piece of blank coin, when placed between the dies. This motion of the screw is communicated through the conical piece F, the upper part of which is acted upon by machinery connected with the steam-engine in an apartment over the coining-room. There are eight of these

coining presses placed in a row on one floor at the Royal Mint.

Each press is contained within four stout oak pillars, rising from the basement to the ceiling of the room. Between these pillars, and attached to transverse iron braces, are placed blocks of wood, against which the lever-arms E E strike, so as to prevent the violent descent of the screw from forcing the hardened steel dies into contact, by which means they might be broken. An ingenious method is adopted for retaining the coin during the moment it is receiving the impression, and afterwards for removing it from the die. The subjoined sketch (*fig.* 89.) gives a side view of this contri-

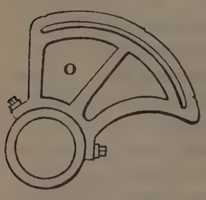
Fig. 89.

vance, as detached from the press: *a* is a steel ring or collar, by means of which the centre of the blank piece of coin is kept exactly to the centre of the dies, while its circular form is also thereby preserved. This collar, passing over the neck of the die, rests upon a steel spring with three prongs, two of which are shown in the cut. This collar is made to rise and fall by means of the two small levers *b b* raised in joints on the boss *c c*, through which the lower die passes. To return to the press: these levers are slit at the extremities, to admit the lower ends of the vertical rods G G G G: the upper parts of which pass through the circular plate H, on the collar of the main screw, so as to rise and fall with it, and thus, by acting by means of the rods upon the levers, to raise or depress the ring upon the neck of the die. When, by the power of the steam-engine, the screw of the press is turned so as to raise the upper die, then, by the action of the rods and levers, the ring is just so much depressed over the lower die as to form a little cell or cavity for the reception of the blank which

has to be placed therein: then, by the return motion of the main screw to make the stroke, the rods ceasing to act upon the levers, the triple spring throws up the collar exactly to the height of the coin, and at the same moment the dies come towards each other, and the impression, at once, is made on both sides of the piece. By the recoil of the press the main screw just rises sufficiently for the vertical rods to act upon the levers besides the die, so as to depress the collar, and leave the coin free for removal. The box K, at the lower end of the screw, and which has a projecting knob made to move through a part of the outer circle of a similar box below it, is designed to allow the screw to turn round a little, independently of the die-box, and by this means prevent that otherwise slurring and injurious motion of the two dies upon the piece, immediately on their separation after the stroke.

We now proceed to shew how the coining press is made to remove every piece of money as soon as struck, and to supply itself with a blank piece. L (*fig.* 88.) is a lever, attached by a pin at M to an upright bar N, rising from the cheek, and braced to the neck of the press: the upper extremity of this lever passes through the groove of a sector, O, attached to the top of the screw, and the face of which is delineated in the margin, (*fig.* 90.): when the screw turns round, the groove in the sector, being of a spiral curve, moves the upper end of the lever L (*fig.* 88.) alternately towards and from the screw, while the lower end, being farther from the fulcrum, moves through a considerable space to and from the press: this lever gives motion to a sliding apparatus P, inserted in a grooved piece Q, attached to the cheek of the press, the slider being so contrived that one of its extremities will move exactly to the centre of the surface of the under die and back again.

Fig. 90.



Figs. 91., 92., 93., and 94. give separate views of this most ingenious apparatus, as detached from the

Fig. 91.

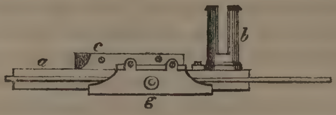


Fig. 92.

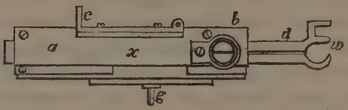


Fig. 93.

Fig. 94.

press. The pieces *a b c* (*figs.* 91. and 92.) compose a kind of socket in which the slider *d* moves: this socket is attached to the press by the pin at *c*: the slider (*fig.* 93.) is made of sheet steel in two pieces, *d e*, which are united by a joint at *f*, thus forming a sort of nippers with a circular cavity at one end, and which, when the instrument is closed, as represented in the cut, grasp the piece of money by the edge, but when opened, allow it to drop out: the limb *e* is opened and shut by the same movement which actuates the slider. A plate *g* (*fig.* 94.) is applied beneath the socket *a b*, and having on its edge, which is turned up beside the edge of the socket, a projecting pin adapted to the fork in the lower end of the long lever above described. By this means the sliding piece is made to move on the outside of the socket, being

laid in a longitudinal gutter, and kept steady by the overlying slip of metal x. The sliding piece is made to move the steel slider within the socket by means of three square studs projecting upwards from the bottom plate (*fig.* 92.): these studs likewise operate in opening and shutting the limb of the slider, as it is carried alternately backwards and forwards by the motion of the lever. The elevation b (*fig.* 91.) represents a slit tube placed upright on the socket: this tube is adapted to receive the blank pieces of coin; it is open at the bottom, so that the lowermost coin of the pile always rests upon the surface of the steel slider. When the main screw of the press is down, or, in other words, at the moment a coin is being impressed between the dies, the slider is drawn back, and the jointed part moved a little outwards, so that the circular cavity at w is exactly coincident with the bottom of the tube b, where it receives and holds fast one of the blank pieces. On the return of the screw, the slider is driven forward over the die, in its progress pushing off the coin just struck, and depositing in its place the blank held in the circular nippers, which, for this purpose, are made to relax their hold as soon as the screw begins again to descend. The descent of the main screw, acting, as before described, by means of the vertical rods, raises the collar on the neck of the die, and thus encloses the coin: at the same time, by the action of the side lever, the slider, having deposited one blank, is taken back in the socket to receive another from the tube by which the press is supplied.

Medals are produced by a succession of operations very similar to those employed in coining. The blanks are generally cut out with beds and punches by means of a fly press: sometimes they are rounded and adjusted with the file, or even cast in plaster moulds: the latter course is occasionally resorted to in making large medallions with figures in very bold relief. The extreme exactness required and attained in the weight of coins at the Royal Mint, by means of the sizing machinery, has already been mentioned. It is, perhaps,

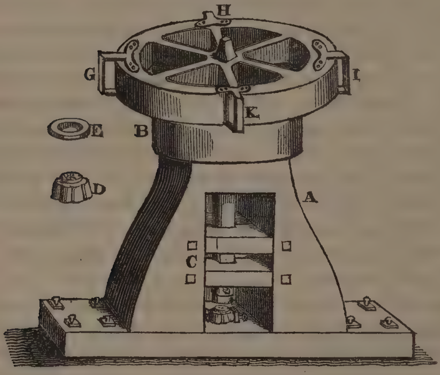
more difficult to attain equal precision in much larger pieces; at all events, it is a point not always attended to by foreign numismatists. Dr. Gregory once mentioned, in a lecture, that "two scientific Englishmen of considerable eminence had just before been complimented by a medal of, he believed, 10*l.* value, by a learned society abroad, on account of some elaborate and very valuable researches. When the medal arrived, it was accompanied, as the lecturer was informed, by pieces of silver coin of more than 1*l.* in value, that the medal, which was cast too small, might, by such 'make-weight,' want nothing of its declared worth!" Who can imagine that any London or Birmingham medallist would have been guilty of such miscalculation? "This case," the doctor justly added, "may be contrasted with the results of the operations of the British Mint; in which he had been assured that on a recent examination, when sovereigns were put to the test as to their weight, it was found that out of 1000, 500 were quite correct, 200 varied only by half a grain, 100 more three quarters of a grain, and the remaining 100 varied altogether a grain!" This is an instance of surprising accuracy; especially when the various processes through which every single coin passes are taken into consideration.

Medals, as well as coins, are sometimes impressed by means of a stamp similar to that used in striking buttons, and figured in the present volume at page 220., and sometimes at the screw press. The former mode is preferred, when the pieces are not of any considerable size, and of so soft a metal as neither to endanger the breaking of the dies by the stroke, nor to require its frequent repetition. In pewter, and, when the blanks are small, in other metals also, a single fall of the stamp hammer is generally sufficient to effect the impression. It was by this method that the immense amount of local tokens, brass, silver, and even gold, at one time in circulation, were manufactured. Few persons possessed of any curiosity on these matters would visit

Birmingham, without going to see the show rooms and workshops of Mr. Thomason, where, along with the making of the most exquisite and costly articles in copper, brass, or-molu, and the precious metals, the manufacture of all sorts of medals is carried on to a great extent: in this interesting establishment the operation of stamping the pieces may be witnessed to great advantage.

When, however, medallions are to be impressed, a screw-press, and mostly of the annexed figure, is employed (*fig.* 95.): A is the body of the press, formed of

Fig. 95.



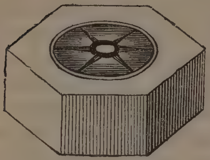
cast iron in a single piece, about four feet high and three feet wide towards the bottom. It is of great weight and strength, to withstand the chance of fracture from the immense power applied when it is in use. Inside the boss at B, works in a brass box a very stout screw, having three or four threads, that it may descend rapidly. The bottom of this screw falls upon, but is not in any way attached to, the top of the piston or thick cubical piece of iron, working smoothly up and down in the guide box C. To the lower end of this

piston is affixed one of the hardened steel dies, engraved *en creux*, with the picture and inscription intended for the reverse side of the medal: the design of the obverse is sculptured in the die D, which is fastened solidly down upon the bottom of the press by means of screws, and in such a position, as that when the upper die descends upon it, their engraved diameters shall be exactly coincident. In order to make a stroke, the steel collar E, the inside of which corresponds with the circumference of the medal, is placed upon the lower die, a small neck being turned thereon to receive it: the blank is then laid inside this collar and upon the die; after which, three or four workmen take hold of the handles G, H, I, K, on the ponderous cast-iron fly-wheel, and turn it so as to wind up the screw, which done, they at once run round with the wheel in the contrary direction, thereby causing the screw to descend with great velocity, and by its action upon the piston, to drive the dies together with immense force. The expansion of the metal, in consequence of the pressure of the dies, will cause it to stick fast in the collar, out of which it is driven by means of a plug of wood and a hammer. The medal, if of silver or brass, is now annealed by heating it red-hot; and when cool, it is pickled in dilute sulphuric acid, after which it is subjected to repeated strokes and annealings, more or fewer as the impression may happen to be bold or otherwise. When the medallion is large, and the figures in a style of very high relief, from fifteen to twenty strokes may be necessary to perfect the impression; and sometimes, for a similar reason, the article is first cast in sand and finished by striking up in the die, in order to give that sharpness of figure and smoothness of surface upon which the beauty of the medallic art so much depends.

The edges of medals are either left smooth, or milled in a manner similar to coins, or else lettered. In the former case, very large medals are sometimes finished separately at the lathe; in the latter the edges are impressed, either by the means of a steel ruler with the

legend engraven thereon, or by the following ingenious contrivance. *Fig.* 96. represents what is called the divided collar, invented by Mr. Droz, for striking money or medals with letters round the edge.

Fig. 96.



The outer mass is a strong hexagonal iron die: into the circular opening in the centre, six steel segments are fitted, leaving, by the arrangement of their inner faces, a space the size of the coin or medal: upon these faces is engraved the legend intended to be impressed. By an interior contrivance the segments are fitted upon centre pins, so that each rises and falls a little as if on a centre.

THE END.

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